THE INSTITUTION OF PRODUCTION ENGINEERS JOURNAL

THE INSTITUTION OF

PRODUCTION ENGINEERS JOURNAL

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ERRATUM

page 662

The article "Education and Research for Production" is concluded on page 724 and NOT on page 715 as stated.

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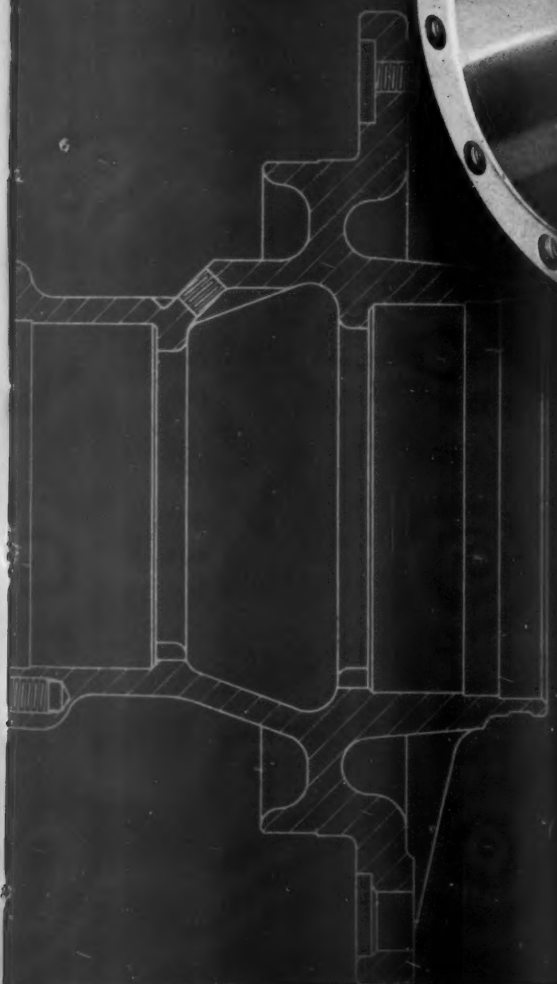

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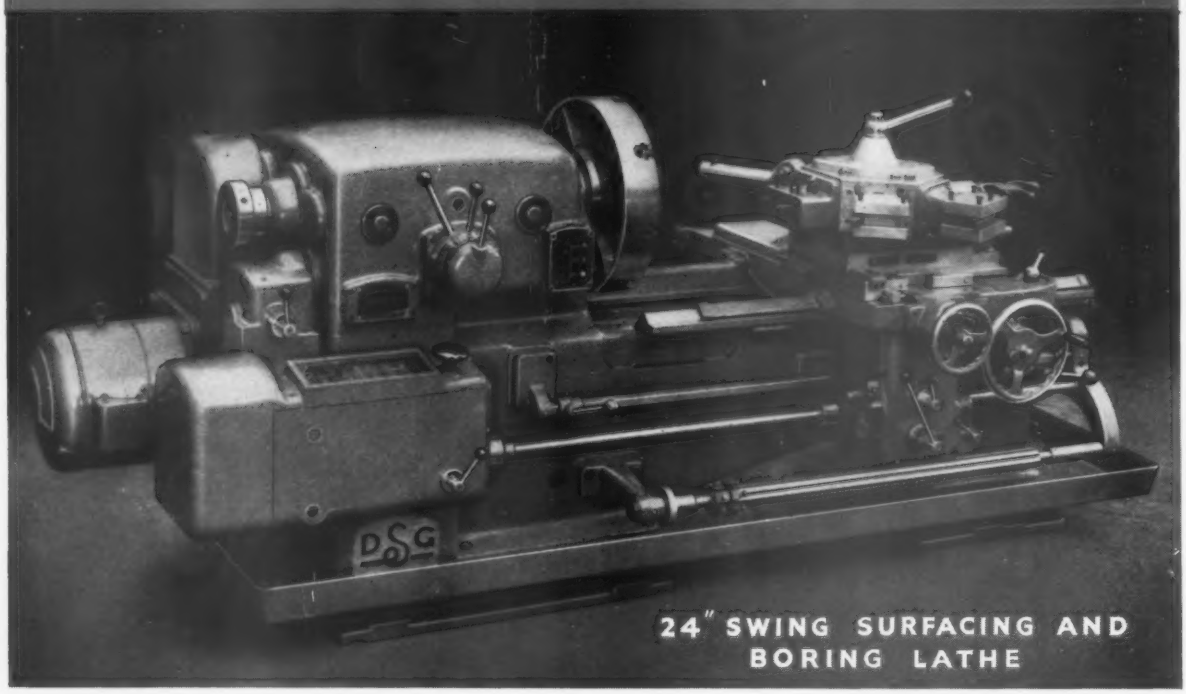

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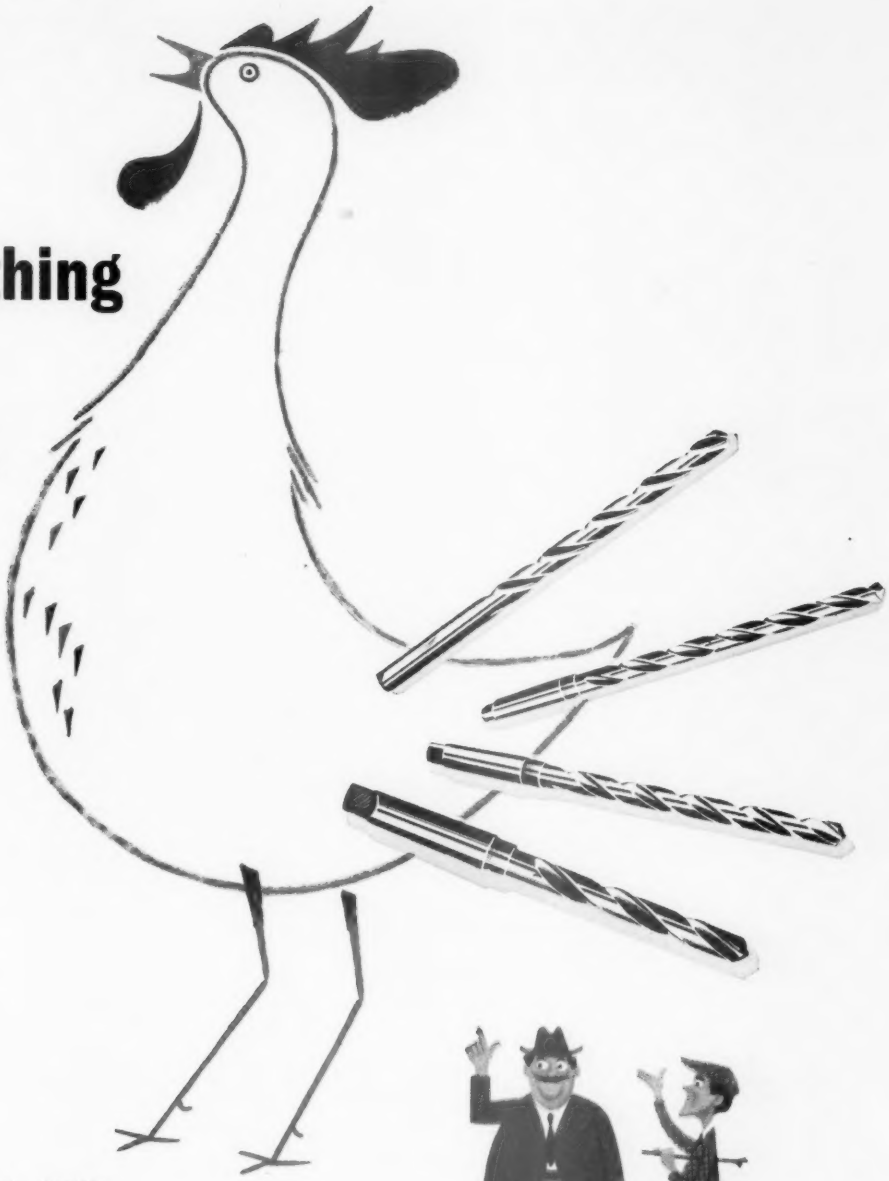

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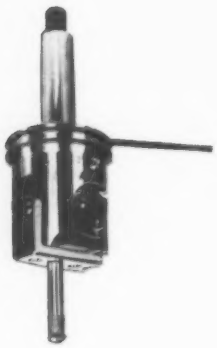

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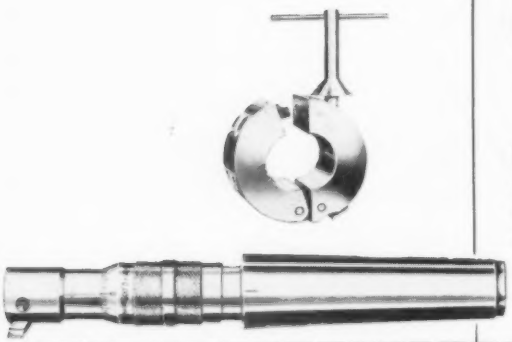

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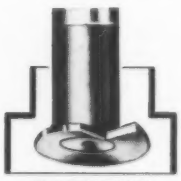

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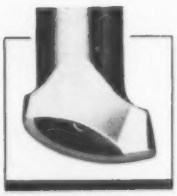

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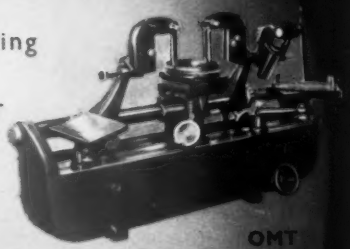

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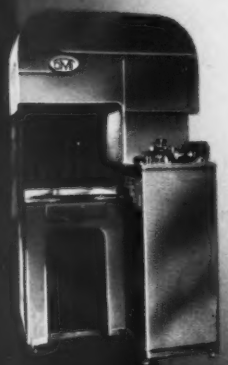

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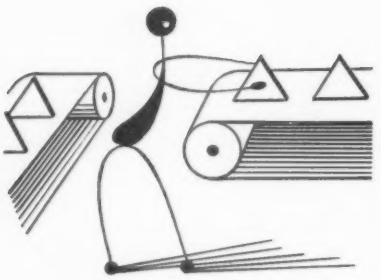
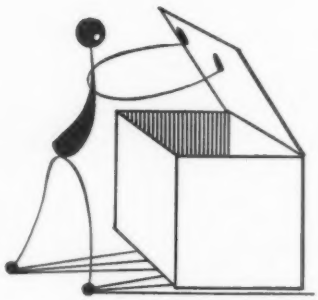


...transfer...



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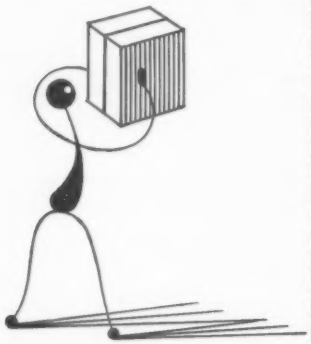
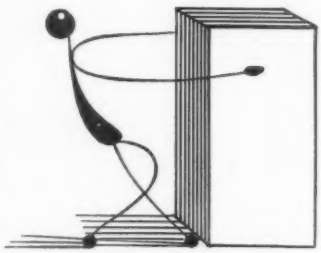
...bend...



...clamp...



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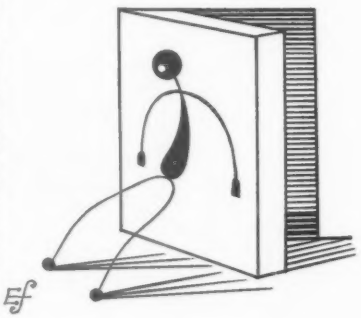

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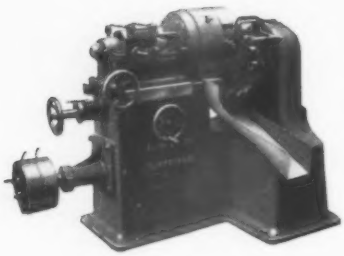

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The Institution of Production Engineers Journal
VOL. 33 NO. 12 DECEMBER, 1954

Education and Research for Production

by Sir BEN LOCKSPEISER, K.C.B., F.R.S., F.R.Ae.S., M.I.Mech.E.

Secretary to the Committee of the Privy Council for Scientific and Industrial Research.

AFTER a few years of grumbling about giving the foreigner the first pick of our highest quality goods, and a priority in many manufactured products which we could make good use of at home, we now all realise the need for maintaining our export trade at the highest possible level. We have always been compelled to export to live, ever since we transformed ourselves from an agricultural community to an industrial nation but when, not so long ago, we were the greatest creditor nation in the world, our balance of payments was not the problem it is now. We live more dangerously today. We are not so well cushioned against the movements of prices in international markets and, in addition, virile competitors have arisen to challenge our old supremacy in manufacture.

Many of the factors which have contributed to the great changes in our economic position have been outside our control. Two World Wars in half a century have exacted their price. The primary producers have gone in for manufacture behind tariff walls, and although economists may question the wisdom of some of these developments, nationalist pride both generates and stimulates the urge. Our competitors, too, in the main industrial countries have not been slow in taking advantage of scientific progress and technological advance.

Are we then to be crowded out? We could be, with an inevitable decline in our standard of living, but there is no fundamental reason why we should be. World trade does not stand still either in quantity or quality. It increases by about 2 or 3% *per annum* and in this expanding international trade manufactured goods account for a steady proportion—about one-third. Further, although primary producing countries now make for themselves many of the goods they previously bought, they want in place the products they cannot yet make. For example, the volume of textile exports has fallen since prewar days, whilst that of exports of textile machinery has risen. No doubt our present customers of textile machinery will, as time goes on, take to making more of their own, but technological progress will give us in due course new opportunities. Even if, for instance, we did not require nuclear reactors for our own electrical power supply, the necessity of achieving the necessary technological excellence for export in so important a field would justify the resources allocated to it.

World Trade Conditions

The conditions of world trade are dynamic in character. There is a persistent trend in the export market towards manufactured goods embodying the more advanced technologies, and the products that come from them tend towards increasing value in relation to that of their raw materials. This is an economic climate in which we can live and prosper, off-setting our poverty in raw materials with the wealth of our native talents, but our talents must be put to full use and good purpose through research, and training in technology and management for production.

In this context the reasons for maintaining a high level of scientific research are obvious enough. A traditional industry can be revitalised by a new discovery. Artificial fibres are a case in point. Rayon, nylon and terylene, all of which come from the research laboratory, have enabled the textile industry to introduce a new variety of products, either from the new fibres alone or from a combination of these and natural fibres to take advantage of the properties of both. New industries can be brought into being. Products such as synthetic rubbers and plastics, industrial solvents, resin rubbers and detergents come from the new petrochemical industry

which yields other chemical products as starting points for further manufacture valuable in export. Research has been lavished on aircraft and engines, and good design and engineering have given us a new export industry of great and no doubt increasing value. The thermionic valve which came originally from the research laboratory has led to a large interlocking group of industries in radio, radar and television and will lead to more wonders yet. There is hardly a branch of science nowadays which cannot be brought to bear on production. The microbiologist is one of the more recent newcomers and the new pharmaceutical industry, based on his research, has given us antibiotics and other products of value to mankind and credit to our balance of payments. All these products consist of large and complex molecules beyond the power of the industrial chemist to synthesise, and research in microbiological genetics may perhaps produce new strains of micro-organisms capable of producing more valuable products we cannot make ourselves.

The Urgent Need for Technologists

But if research is the goose that lays the golden eggs, the goose is quite incapable of hatching them out. Research cannot put a single aeroplane into the air or set a production line going. This is the business of a different sort of animal—the technologist who is concerned with design, production and management. We are good at research (the goose is in good trim and will go on laying provided she is properly fed and cared for) but it is strange to reflect that the best educational system in the world has failed to give us a sufficient supply of technologists. We are not so noticeably short of other kinds of professional men and the fault *(dear Brutus)* lies not in the system, but in ourselves. We have only recently recognised the need in industry for so many technologists of different kinds, and even advanced and highly efficient industries which formerly used to breed their own are now apprehensive about the supply of top flight technologists who can translate laboratory results in terms of effective manufacturing practice. This kind of person can only come from specialised post-graduate training and in an environment that induces an outlook and philosophy consonant with industry, which, however liberal and imaginative, has to count the cost. Good science is not always good business, and in the final analysis the cost of production determines the issue.

The steps now being taken to extend significantly the facilities for post-graduate technological studies at our Universities are sufficient evidence that we are alive to the necessity in these fields of study, but it is doubtful whether the extent and variety of the needs are yet fully appreciated. These are illustrated and underlined by the rapid strides made in the last few years in techniques of automatic control and operation. The oil, chemical and food processing industries have been steadily moving away from batch processing to continuous operation embodying a measure of automatic control, and the metal using industries in their engineering shops are moving in much the same direction, the logical end of which lies in the fully automatic plant or factory. The fully automatic electronic digital computer is emerging from the research laboratory, where it had its origin, as a master mechanism to integrate and control automatically, the discrete steps hitherto involved in the process industries and in the manufacture of engineering products. There is a good way to go before highly complex techniques such as these can be reliably and generally established, but this is the way things are likely to go, and we can anticipate the need for not only many more high class development engineers than we consider necessary even today, but for more people trained in both management and technology. These new developments will, on the one hand, add power *to* management by providing it with electronically calculated data otherwise inaccessible and, on the other hand, add to the demands *on* management. The solution of problems of reorganisation, based on electronic techniques, both in business offices and factories will be urgently required if the advantages of fully automatic working are to be had. These revolutionary conceptions are already taking shape and the demands of education in management, for the type of production ahead of us, are most likely to be met by bringing knowledge in the art and science of management to those already skilled in the practice of technology.

But whilst many are concerned, and rightly so, about providing the kind of education and training which meets the need for the highest quality, others are equally concerned with the more diffuse problem of introducing a technological stiffening in industry at all levels. One cannot generalise about British industry, or indeed about the industry of any country, without qualifications. The technological spectrum ranges from technical illiteracy to the most efficient practice, and our best

(concluded on page 715)

THE INVESTMENT CASTING PROCESS

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Mr. Tedds

THE term " investment casting " may be defined as a metal casting process employing an expendable pattern in conjunction with a one-piece mould made of ceramic material.

Until quite recently it was generally believed that the process, often referred to as the " cire perdue " process, was very ancient and used by the Samian artists. Kurt Kluge (1) first put forward the theory that it came much later. He called attention to the fact that the immediate technical predecessors of bronze statues were the plated figures fitted on to wooden cores and from a close examination of all large 6th century bronzes, he was convinced that they were cast not from any model by the wax process but from wooden originals from which a sand cast was made. He believes that a perfectly logical development from plated wooden statues to bronze cast on the cire perdue principle took place, and gives a logically developed series of inventions which all culminated in the final, intricate and elaborate process which in substance has remained unaltered and incapable of alteration down to to-day.

Casson (2) agrees with Kluge. He believes that the Greeks of Hellenistic times were the discoverers of this method and quotes the example of the Charioteer of Delphi, in which the bell-shaped skirt below the waist as well as the main upper part of the body and drapery are all cast from a wooden original, while the head, arms and feet are separately cast by the cire perdue process.

Theophilus (3) details the process as used in the 11th century and Benvenuto Cellini (4) gives an account of the lost wax process as used by himself and his contemporaries, Raphael and Stradivarius in the 17th century.

In 1897, an American dentist, B. F. Philbrook (5) of Iowa, used the process for making gold inlays and it was only to be expected that the jeweller soon realised the possibilities and used it for producing the intricate shapes coupled with smooth surfaces and minute detail.

In 1929, R. W. Erdle and C. H. Prange of America, developed and cast a cobalt base alloy, both full and partial dentures being produced. In 1935, production of bone surgery appliances by this process was undertaken. The year 1940 saw its development in the industrial field with the production of aircraft parts, and 1942-43 its introduction into Great Britain.

Since being put on an industrial basis the process, whilst remaining basically stable, has made tremendous strides especially with regard to the equipment utilised at the various stages of the process, and the rigid technical control exercised at all points. By this means consistency in the quality coupled with a higher rate of production has been made possible.

The various stages of the process for producing castings in steel and high melting-point metals is outlined in Fig. 1 and illustrated in Fig. 2.

THE PROCESS

Die Manufacture

The first step in the investment casting process is the production of a die containing the negative shape of the pattern, from which the expendable patterns are produced. These dies must be so designed that each section "peels away" from the fragile patterns. Provision must be made for guiding their separation, until all details of the pattern have been cleared and, in complicated and multiple-piece dies, a series of dismantling operations is evolved whereby stressing of the warm and pliable patterns during extraction is eliminated.

One of the first decisions which has to be made is whether to make a master model and cast a die from it or sink a die directly from the blue print. The factors which influence this decision are :-

(a) Dimensional tolerances desired in the final castings.
Greater accuracy is possible from a machined die than from a cast die.

(b) Complexity of the item.
The more complex the item, the greater the number of pieces constituting the die. Low melting point metal dies are most suitable for two-piece or book type dies; machined dies for multiple-piece dies.

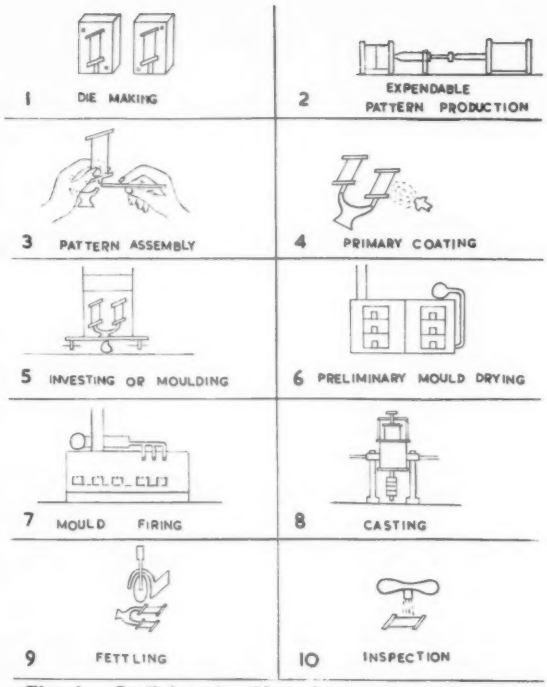

Fig. 1. Outlining the 10 major stages of the process.

(c) Number of components required.
For long production runs involving approximately 10,000 patterns, it is more economical to sink a steel die since its die life is so much greater than that of a cast die.

Cast Metal Die

The cast metal die is capable of considerable accuracy but also has a limited operational life. Being relatively soft, it is easily damaged and repairs are a

Fig. 2. Pictorial view of various stages of the process (including sectioned moulds).

		Cerrobend	Cerrosafe	Cerromatrix	Cerrobase	Cerrotru	Cerrocast
Composition	Bismuth %	50·0	42·5	48·0	55·5	58·0	40·0
	Lead %	26·7	37·7	28·5	44·5	—	—
	Tin %	13·3	11·3	14·5	—	42·0	60·0
	Cadmium %	10·0	8·5	—	—	—	—
	Other	—	—	9·0 Sb	—	—	—
Melting Temperature °F.		158	158/194	217/440	255	281	281/338
Weight lb. per cu. in.		0·339	0·341	0·343	0·380	0·315	0·296
Tensile Strength lb. per sq. in.		5,990	5,400	13,000	6,400	8,000	8,000
Elongation % on 2" (slow load)		200	220	1	60–70	200	200
Brinell Hardness		9·2	9	19	10·2	22	22
Cumulative growth and shrinkage per inch on test bar ½" × ½" × 10".	Time after Casting: 2 mins.	+ ·0025	— ·0004	+ ·008	— ·0008	+ ·0007	— ·0001
	30 mins.	+ ·0045	— ·0009	+ ·0047	— ·0010	+ ·0006	— ·0001
	1 hr.	+ ·0051	·0000	+ ·0048	— ·0008	+ ·0006	— ·0001
	5 hrs.	+ ·0051	+ ·0018	+ ·0049	·0000	+ ·0005	— ·0001
	24 hrs.	+ ·0051	+ ·0022	+ ·0051	+ ·0008	+ ·0005	— ·0001
	96 hrs.	+ ·0053	+ ·0025	+ ·0055	+ ·0015	+ ·0005	— ·0001
	500 hrs.	+ ·0057	+ ·0025	+ ·0061	+ ·0022	+ ·0005	— ·0001

Fig. 3. Composition and Properties of some Low Melting Bismuth Alloys.

frequent necessity. Also, dies made in low melting-point metal are easily distorted under pressure. Great care must be taken to reinforce the dies with steel plates and frames in order to withstand the clamping pressure and prevent the metal from creeping and spreading, which affects the dimensional consistency of the expendable patterns.

The manufacture of this type of die is initially commenced by the production of a master model or pattern. The master model is usually a specially machined replica of the final casting, plus shrinkage allowances. No exact shrinkage allowance can be established for estimating the shrinkage to be incorporated in the construction of dies for handling patterns. They vary depending upon the shape and design of the component and must take into consideration the shrinkage of the expendable pattern, the expansion of the investment or refractory forming the mould and the shrinkage of the casting alloy. Where a component is free to move in all directions, when in the "expendable pattern" stage or "as cast" condition, a usual allowance is 0.025" per inch. Where complete restriction is present, this figure may be reduced to 0.015" per inch. From this it will be realised that varying contraction figures are possible at different stations and across various dimensions on a particular component. The solution of each new design must be predicted upon past experience in handling similar problems. The first point that must be borne in mind is that "no casting can be more accurate than its master model or die". In rare instances existing parts can be used as master models, providing there are no objections to the finished castings being at least 0.015" per inch smaller on all dimensions.

The actual die is produced by embedding the model in plastic clay to its established parting line. Reverse halves of the die are then formed in Plaster of Paris and on to these is cast a low melting point fusible metal, thus forming the two halves of the die in metal. The most suitable materials for soft metal die production are the bismuth alloy series. These alloys possess the essential property of having the minimum of shrinkage on solidification coupled with a relatively low melting point. Typical compositions and their shrinkage characteristics are given in Fig. 3.

Machined Dies

These dies are produced by conventional methods and offer the greatest accuracy obtainable in the expendable pattern and also the maximum die life. Steel dies are the most attractive from an all-round standpoint, but aluminium dies are quite satisfactory if weight becomes an important factor. A composite machined die is shown in Fig. 4, the centre section being produced in aluminium alloy and the outer sections in steel.

An important feature of all die design is the inclusion of gates and runners. This standardises the complete assembly, minimises or eliminates pattern assembly and reduces surface undulations, thus giving smoother entry of metal into the mould cavity.

Fig. 4. A composite machined die for producing nozzle swirler.

Pattern Materials

A variety of materials can be and has been used for the manufacture of the expendable patterns. Those which have been tried include wax, plastic, frozen mercury, low-melting point metals and sulphur, the two former being the ones commonly used in production.

Each has certain attractive features, but wax offers the best all-round properties.

Waxes

A wide variety of waxes is used for compounding a material suitable for pattern production and the various ingredients, e.g., carnauba wax, Flexoresin, paraffin wax, etc., all have special effects, together with the order of addition, on the properties of the final product.

These can be compounded to give mixtures with varying properties and those most suitable for all round use are given in Fig. 5.

Instead of compounding waxes to a particular formula, a number of proprietary waxes are available which give excellent results and the following properties are given as being typical :-

Setting point	53°C.
Comparative strength (Paraffin wax 1) ...	1.6 - 1.9
Contraction from 5°C. above setting point to 20°C. ...	4.2%
Ash	0.08%

With regard to the selection of the most suitable wax, one factor must be observed closely. All waxes have different shrinkage characteristics and once a wax is decided upon and injection dies made to suit those characteristics, it may be impracticable to change the wax composition without either modifying the dies or making new ones. This means that a great deal of experiment and thought should be carried out before finally selecting the wax or pattern material which will be used in production.

The advantage of using wax as the pattern material may be listed as follows :-

1. Waxes have low melting points (45 - 70°C.) and therefore constitute a lesser industrial hazard, e.g., burns to operator, etc., than the higher melting point materials. They are very fluid and flow readily into the die.
2. The wax patterns can be assembled into casting formation quite readily by using hot knives, spatulas, etc.
3. Small nicks, holes, flow lines or similar defects can be readily repaired by means of hot tools or filler materials.
4. The wax which flows out of the mould can be reclaimed (approximately 60%) and re-used for making sprues, runners, gates, etc.
5. Dies for wax patterns can be made more cheaply than for those of other materials, e.g. plastics, which require heavy steel dies owing to the higher injection pressures.

The disadvantages of wax as a pattern material may be enumerated as :-

1. The patterns are fragile, especially in thin sections, and must be handled carefully to avoid chipping of edges, scratching, etc.
2. They become brittle if stored too long and shatter readily on handling.
3. Owing to the low melting point and expansion characteristics, it is imperative that wax patterns are made, assembled and stored in a temperature controlled room (60 - 65°C.) since

Mixture	Setting point	Comparative Strength	Contraction 5°C above setting point to 20°C.
30% Paraffin wax 60°C 30% Ceresin 17% Carnauba 23% Flexoresin	62°C	2.75	7.3%
70% Paraffin wax 60°C 20% Flexoresin 10% Carnauba wax	59°C	3.30	6.0%
60% Paraffin wax 65°C 15% Carnauba wax 25% Flexoresin	63°C	3.30	5.0%

Fig. 5. Compositions of typical injection waxes.

a noticeable change in air temperature may cause production difficulties and an alteration in dimensional size before the patterns are moulded.

Plastics

The usual plastic used for producing the expendable pattern is polystyrene, a thermo-setting type of plastic with a sp. gravity of 1.07 and shrinkage 0.002″ - 0.008″ per inch in injection. It does not flow freely, as does wax, but softens at 90°C. It is soft enough to flow at 200°C., and runs reasonably freely at 300-320°C. Owing to its viscous nature relatively high injection pressures are necessary, which means it is not possible to employ low melting point metal dies, but machined steel dies must be made for each new component. Thus, the cost of setting up for injection of plastic patterns is expensive both from cost of machines and from the cost of sinking the steel dies.

Other disadvantages of plastic patterns are that, if the surface is damaged, they cannot be repaired as can wax; the assembly of the patterns into casting formation is more difficult than when joining wax patterns; they have a pronounced tendency to cavitate upon solidification, thus precluding their use for patterns involving wide section differences and they are also prone to warpage on standing.

Frozen Mercury

The use of frozen mercury as the expendable pattern material has attained some success in America for certain applications. The main asset attributed to this technique is the absence of solidification shrinkage and the ease with which pattern assembly is carried out, since two pieces brought into contact are instantaneously bonded and cannot be taken apart without destroying the unit. However, commercial applications of this process have been inhibited by the complications encountered in attempting to operate at temperatures as low as -130°F. The dies, jigs and other fixtures must be made of material which will withstand amalgamation, e.g., steel or aluminium, and performance of these parts is subject to considerable variation at these temperatures.

Low Melting Point Metals

Attempts to use metal-alloy patterns of similar composition as listed in Fig. 3 have not met with commercial acceptance. This is owing to the difficulty of ensuring complete removal of the bismuth alloy from the face of the mould cavity. Firing of the mould to 1000°C. does not completely eliminate it and washing the mould cavity with mercury to form an amalgam is not fool-proof, nor does it constitute a production process.

Sulphur Compounds

These have been suggested as being possible pattern materials, the sulphur being combined with graphite or naphtha compounds. Whilst they produce patterns which have excellent surface finish and a minimum amount of shrinkage, their high melting points (90 - 110°C.) present extra industrial hazards and the sulphur dioxide fumes formed during mould burn-out also create some production problems.

Fig. 6. Fully automatic wax injection machine.

Pattern Production

The metal die is coated with a thin film over its cavity faces with either machine oil, mutton tallow, neat tetraethyl silicate or silicone mould-release fluid and assembled ready for the injection of the pattern material.

The machines suitable for this operation are shown in Fig. 6. The machine consists essentially of a wax tank (3½ gallon capacity), electrically heated and oil jacketed with a thermo-syphon circulation of oil through the body of the wax to give even heating.

The worktable on which the dies are placed is mounted on the ram of an hydraulic cylinder on which it is raised into the injection position by depressing two push buttons on the instrument panel, a triple variable time sequence opening the wax tap. Wax commences to flow from the low pressure system (80 lbs./sq. in. max.) followed at a variable time by the operation of the high pressure system (500 lbs./sq. in. max.), which can remain in action for up to 2 minutes.

Thus, with this type of machine the four important factors affecting pattern quality are controlled, viz. :-

(1) close temperature control of pattern material;
(2) controlled speed of injection;
(3) pressure available as material cools in the die;
(4) controlled "dwell" time of the pattern in the die.

Fig. 7. Assembling wax patterns by means of hot spatulas.

One point of some practical importance when using this machine is the position of the injection hole in relation to the mould cavity. This must lead the wax in at the lowest point, thus minimising turbulence and the occurrence of air holes in the resultant patterns.

Pattern Assembly

Having produced the dispensable patterns, the next stage of the process entails the assembling or clustering of them into casting formation. This may take the form of joining a number of patterns to a main runner, the fixing of the feeders, gates, etc.

Joining Wax Patterns

This is accomplished by the use of a hot tool, e.g., spatulas, dental tools or knives of appropriate shape (Fig. 7). The heated end of the tool is placed against the mating surfaces and as soon as the wax is molten, they are quickly pressed together. The joint can be smoothed over with the hot tool, but a ridge or uneven section is invariably left where it is applied. This is not harmful if the ridge appears at a point where the casting is to be machined or the metal is to be discarded.

Assembly Methods

Although hand methods are employed to a considerable extent, this can lead to serious faults. It introduces the human element into an operation which needs great care and high accuracy and limits the closeness with which patterns may be spaced. Fixtures, often of simple construction, in wood, soft metal, etc., are used wherever possible, entire assemblies being laid in the fixtures and the component pieces joined by the use of hot tools or molten wax (Fig. 8).

Assembly Considerations

The mounting of patterns into casting formation is dependent on several factors, among which are the following :-

(1) economy, i.e., placing as many patterns as possible in one mould. This is governed by a number of things, chief among them being the ease with which the patterns may be mounted and with which the gates and risers can subsequently be removed from the castings. There is also a minimum limit of about $\frac{1}{8}''$ of investment material which should be between any two cavities at any point and about $\frac{3}{4}''$ between the cavity and the outer edge of the mould.

(2) casting ability, i.e., the ability of the metal to fill the mould cavity and freeze progressively from the patterns to the feeders. It is obvious that the gates and runners must be properly placed in regard to the contours, accuracies and other properties desired in the casting. As in normal foundry practice, the ideal gating method is one in which the temperature gradients are so balanced that the entire casting cools and completes its shrinkage while the metal in the feeders is still molten, thus causing the final shrinkage cavities to be contained therein.

Gating Methods

Precision investment castings are produced mainly by the direct air pressure process and by gravity pouring.

When the direct air pressure casting method is employed, the majority of castings are produced by top-running and feeding techniques. Having taken into consideration other phases of the process, e.g., primary coating application, moulding characteristics, ease of fettling, etc., the running and gating method is evolved accordingly. The main runner, which also acts as a feeder, is usually truncated cone in shape, approximately 2 - 3″ diameter at the base and 2″ high. To this may be attached cross feeders, which gradually taper off into the cross section of the casting or subsidiary runners which feed each individual casting. Gate and runner sizes, positions and shapes are largely matters of trial and error based on accepted general rules and experience.

Risers, when they are employed, are usually blind and contained in the investment. Open risers are rare. The controlling factor on the size of riser employed is often the strength of the expendable pattern, since it must be capable of bearing the weight of the riser sections. The position of the gates and runners, apart from their feeding potentialities, must also be considered from a dimensional aspect. The runners form hot spots in the mould and as such, create casting stresses with consequent possible distortion of the casting.

Much of the above applies when gravity casting methods are employed. The most significant point, however, is that, owing to the slower velocity of the metal, it is usual to increase the size of the runners, gates and feeders, over those normally employed for pressure casting techniques. The ratio of casting weight to runner-feeder is on the average 40 : 60 when pressure casting, but when gravity pouring is employed the yield ration may be as low as 20 : 80.

Moulding Considerations

When moulding or investing, the pattern assembly is standing on its base. It is thus important to avoid having blind recesses, undercuts, etc., in such a downward position that they will entrap air and prevent the vibration from removing it from the investment. Should this happen, air pockets are formed in the mould leaving little or no support for the primary coating. On pouring, the metal breaks through, forming a ball of metal which has subsequently to be removed on the fettling bench. In a great many instances, the easiest and most economical method is to position the patterns so that these pockets or surfaces cannot entrap the air. This may produce difficulties when planning running techniques and reduce the number of patterns which could be assembled within a given size mould, but it must receive full consideration.

Fettling Problems

The castings must be cut off the runners and gates. If an abrasive wheel or a friction saw can run in a straight line and sever each casting in one operation, it is simple and inexpensive. If a number of subsidiary cuts have to be made, the fettling time is increased. Another consideration is whether the castings can be removed by manual operation, or if a fixture will be required. This point alone may dictate the shape of the pattern assembly and of the flask which it fits.

PRIMARY COATING

The next operation in the process is the coating of the pattern assembly with a refractory material bonded with a suitable agent. This coating ultimately forms the facing for the mould cavity and as such is the "facing sand" or "mould dressing" in the investment process.

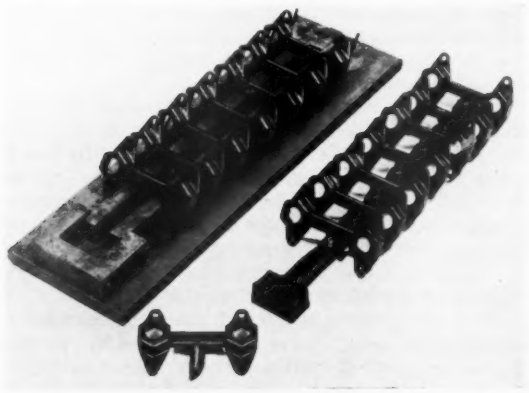

Fig. 8. Fixture for clustering a number of small components.

When casting steel and high melting point alloys, it is usual to employ high grade refractories as the filler. Silica was first suggested and tried and whilst suitable for a number of stainless steels, it reacted readily with some of the high-temperature alloys especially those containing titanium. Zirconium silicate, which has a higher fusion point and superior qualities to silica, can be used successfully when casting a number of high-temperature materials but here, again, certain steels give a reaction, thus limiting its field of application. The least reactive materials and ones used with considerable success are the basic refractories, alumina or magnesia.

The refractory fillers are bonded with a suitable bonding agent, the two usually employed being sodium silicate or hydrolysed ethyl silicate.

The refractory filler and bonding solution are mixed in certain proportions, depending upon the technique of application, i.e., by dipping or spraying methods. Typical compositions are :-

Dipping	*Spraying*
Refractory filler - 2½ lb. (-200 mesh).	Refractory filler - 1 lb. (-200 mesh).
Bonding solution - 1 pint	Bonding solution - 1 pint

Coating Methods

The two main methods for applying the primary coating to the pattern assembly are :-

(a) by dipping
(b) by spraying

Dipping methods are most suitable when inaccessible areas are present in a particular pattern or assembly. The clusters should be pushed rather than plunged into the investment, time being given and movement applied in order to displace the air. After dipping, the assembly is drained in order to eliminate excess material and prevent undue thickness of the coating. The main disadvantages of this method of application are :- (a) the possibility of air bubbles being trapped in the coating; (b) the coating does not lie as close to the pattern as one produced by the spraying technique, thus affecting the quality of the surface finish of the final casting; (c) the coating varies considerably in thickness from face to face on the pattern and falls away on sharp corners and edges; (d) longer drying times are necessary.

The spraying of the primary coating over the pattern assembly by means of a pressure feed spray gun is to be preferred to the dipping method.

The advantages gained may be listed as follows :-

(a) there is close contact between the coating and the assembly, thus giving maximum surface reproducibility;
(b) there is no tendency for entrapped air bubbles to lie on the pattern surface;
(c) there is a greater measure of control over the general thickness of the coating and less possibility of "tear formation" or dripping.

Fig. 9. Moulding of wax patterns, showing the vibrating units and investment mixing machine.

MOULDING OR INVESTING

Having dried the primary coating, the pattern assembly is ready for moulding or investing.

The pattern is attached to a metal plate and a metal moulding box, usually a steel cylinder open both ends, placed over this and clamped in position. The unit is then ready to receive the investment material (Fig. 9).

Investments

In general, investments are mixtures of graded particles of refractory material, e.g., crystobolite, sillimanite, mullite, magnesite, zirconia, and a binder. When mixed with water or some other suitable vehicle, a semi-liquid mass is formed which is easily compacted into a mould. The mixture must have sufficient working time to allow for handling and packing of the refractory aggregates around the pattern assembly and then be capable of setting into a hardened mass as quickly as possible. The refractory used must not contain impurities which would react with or be fused by the molten metal. When moulded it must be hard enough not to erode during pouring, yet should be sufficiently soft to allow the casting to contract while cooling without fracturing.

Refractory Aggregates

For steel and high temperature alloys, the most widely employed investment material consists of mixtures of alumina and silica, e.g., sillimanite, alumina grog, prepared clays, etc.

In any investment it is important to control particle size, and it is necessary to have the correct balance between coarse particles (–16 mesh to +100 mesh) and fine particles (–200 mesh), since the refractory mixture will affect not only the surface finish of the castings but will significantly influence the inherent resistance of the mould to develop cracks during the firing and casting operations. A mould consisting of all coarse aggregates will not crack on firing, but owing to the high percentage of voids present will be weak and friable. The coarse aggregates alone also form poor support for the primary coating and castings with rough, scabby surfaces are generally produced from such a mould. A large proportion of fine aggregates will result in a large surface area per volume and thus a large volume of binder is absorbed by the particle surfaces, with a correspondingly greater shrinkage taking place as the binder is dehydrated. Also, the finer the refractory particles the greater their tendency to remain in suspension in the binder, thus increasing the necessary vibrating time in order to produce a suitable mould.

It is obvious that for gravity casting, a more permeable mould is desired, thus warranting a higher percentage of coarse aggregates being introduced. When direct air methods of casting are to be employed, a strong mould is necessary thus calling for a reduction in the percentage of coarse aggregates and an increase in the finer grade.

Mixing of Refractory Aggregates

The compounding of the refractory investments is accomplished while the ingredients are dry. If new sand is to be used continuously for the production of each mould, then a rotary mixer of the barrel or drum type is ideal for the operation. If reclamation of a proportion of the used mould materials is to be

attempted, then a fixed pan type of mill with two rotating rollers offers the best solution. The rollers are raised from the face of the pan to leave ½" - 1" gap. This prevents all grinding action but crushes the larger pieces of reclaimed mould material.

The ratio of reclaimed material to new material will vary with the type of sand used and the aggregate analysis, but an average figure is in the region of 50% reclaimed material + 50% new material.

Binder

Various types of binders have been used for producing strong moulds, suitable for casting. The first one employed consisted of hydrolysed ethyl silicate diluted with ethyl alcohol. This proved to be expensive, difficult to control under production conditions and highly dangerous in use, and has now been superseded by water-base binders, e.g., sodium silicate; Portland cement, etc.

Mixing of Investments

When the bonding solution or dilutent and the refractory aggregates are mixed, enough of the former must be added to attain a smooth flow of the mixture so as to permit complete fill-in against the pattern assembly.

It is standard practice to weigh out a certain amount of dry refractory mixture and measure the requisite amount of liquid. The ratio varies from refractory mixture to refractory mixture depending on the grading of the aggregates, but an average ratio is approximately 160/200 ccs. for each one pound of refractory. A machine which has proved most suitable for mixing the investment is shown in Fig. 9, the mixing being completed in 1 - 3 minutes. The final mixture is poured carefully into the moulding box or flask and the complete unit is ready for vibrating.

Vibrating

The purpose of vibrating the investment after it is poured into the moulding box is to pack the refractory grains into contact with one another and so force the excess liquid to the top of the flask, where it may be poured off.

Vibration as applied to an investment has several control factors. Principal among them are direction; amplitude; frequency and time.

Direction

The usual direction of the vibration motion is vertical which causes the refractory particles to settle. When the principal direction is horizontal, there is a separation of the various particles with little or no compacting action. Other methods have been used, e.g., circular motion coupled with a tamping action, but little or no advantage has been observed.

Amplitude

This means the distance which the material travels in one cycle of the vibrator. High amplitude can cause the mould investment material to fracture the primary coating owing to the impacting action created. It can also cause air to be introduced into the investment and, at worst, shake the patterns from the pattern-assembly. It also tends to have a separating action on the various particles of the investment and the general rule is to work at low amplitude coupled with high frequency. Amplitudes as high as 0.032" have been used, but a more general figure is about 0.010". When high frequencies are used the top limit is 0.001" - 0.002".

Frequency

Frequency is measured in cycles per second and has the compacting effect of pressure. Thus the higher the frequency, the greater the pressure. Frequencies used vary from 4 to 100 cycles per second, with 30 to 100 the usual figure.

Time

This is the period over which the vibrating is continued. It varies with the grain size of the investment, the amplitude and frequency of the vibrator and the height of the final mould, but an average time is approximately 20 minutes.

A suitable machine, electrically operated, is shown in Fig. 9. It is electro-magnetic in operation, strongly constructed of welded steel units and designed to have no wearing surfaces. The table top is cantilevered on powerful springs which are firmly attached to the base and vibration results from the resonant plucking of these springs by electro-magnets powered by alternating current. Vibration is at 6,000 cycles per minute, i.e., 100 cycles per second and amplitude is controllable from 0.002" to 0.025" by varying the voltage to the magnet coils. The table will vibrate a load of 10 cwt. and at full amplitude takes about 10 amps.

The main advantages of this machine may be listed as :-

1. its constant high operating frequency allowing faster compacting rates during investing;
2. no mechanical wear and accurate repetition of vibrating conditions;
3. uniform vibration over the whole of the table.

MOULD DRYING AND FIRING

After the investment has been consolidated in the flask, there is a three-stage operation that is necessary to prepare the mould for casting :-

1. removal of the mould from the vibrator and a minimum period of air drying (usually 2 to 24 hours) commensurate with the formation of the gel during the initial set of the binder;
2. low temperature drying and pattern removal;
3. burn-out or firing of the refractory material.

Low Temperature Drying

Where wax patterns are used the low temperature drying of the mould is carried out in a forced air circulating oven, fitted with suitable heating and time-temperature recording equipment (Fig. 10).

The maximum temperature necessary for water base binders is 140°C., the time at temperature varying with the size of the mould. It is usual for the moulds to be loaded into the oven at room

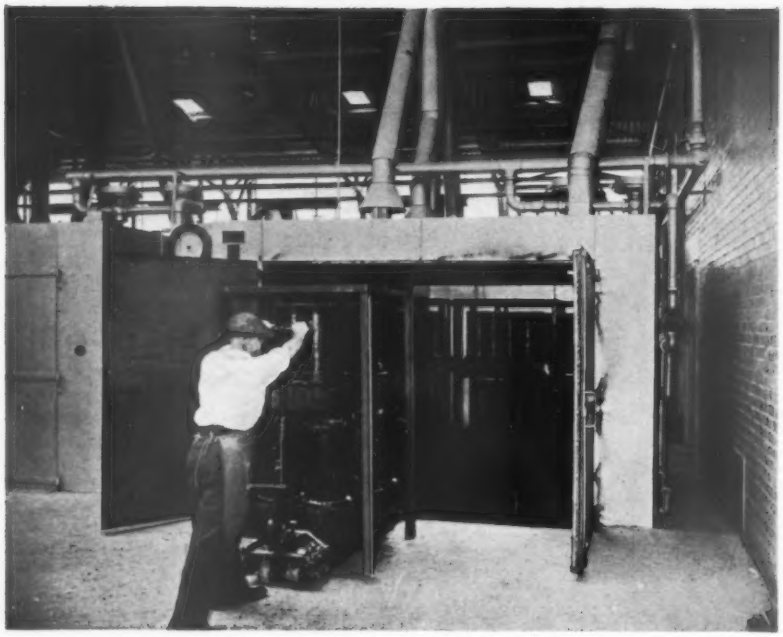

Fig. 10. Loading moulds into the low temperature drying ovens.

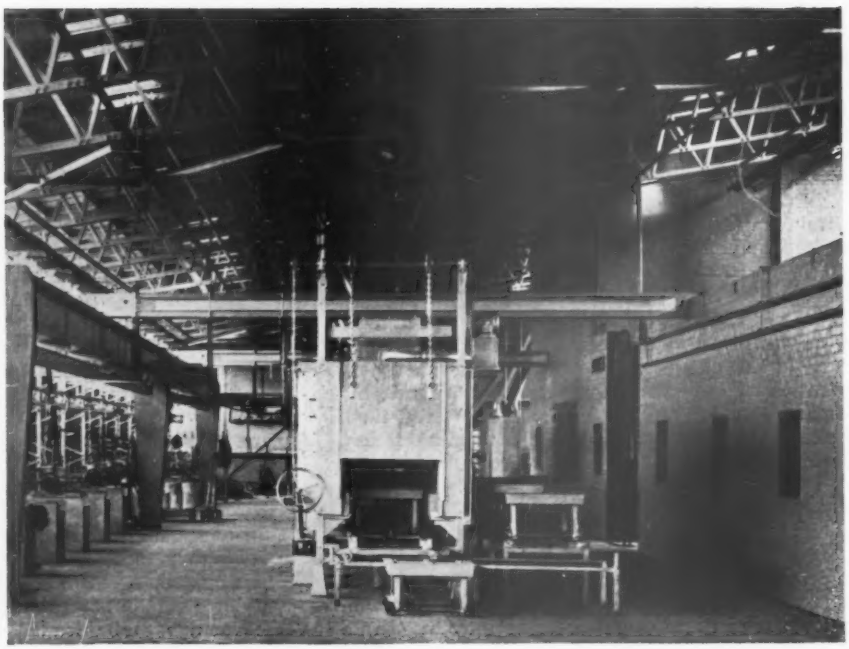

Fig. 11. Charging end of high temperature mould firing oven.

temperature with the runner in the downward position, thus allowing the wax to drain out as it melts. The temperature of the oven should reach its maximum in a period of 4 - 6 hours, and for moulds up to 10″ diameter, maintained at that temperature for a further 6 hours. During this treatment, the mould hardens considerably and the wax melts out. The recovered wax, which may amount to 50/75%, is suitable for the production of runners, feeders, etc., or may be refined and used for pattern manufacture.

If the moulding box is not to be heated with the mould during the burn-out stage and has been suitably waxed prior to moulding, it may conveniently be pressed off after the low temperature drying cycle.

Mould Firing

There are two main reasons why the mould is fired to a temperature of 1000°C. First, it is necessary to eliminate the last vestiges of the expendable pattern and mould liquid. There is always some of these materials left in the mould after it has come from the low temperature oven. The second reason is to provide a hot mould in order that the metal will run and completely fill the mould cavity and reproduce the fine detail and good surface finish.

The method of firing the mould is by use of the continuous or moving-hearth type of furnace (Fig. 11). This is the ideal production furnace if the sizes of the moulds do not vary too much, since it can operate 24 hours a day with no loss of time for cooling, loading and re-heating. The warm moulds from the low temperature oven are loaded at one end, progressed through the furnace in 3 - 10 hours and emerge at casting temperature.

MELTING AND CASTING

Indirect Arc Furnace

The majority of melting furnaces for investment casting have been developed on the principle of the Detroit rocking arc furnace. It consists of an outer metal casing, lined with a suitable insulating material and a crucible (5 - 20 lb. capacity). A clamp is attached to the top plate of the furnace and is used for holding the mould in position during the casting operation. A series of balance-weights is attached to the base of the furnace and the whole unit mounted, by means of trunnions and rollers, on a cast iron stand (Fig. 12). The furnace is powered from a 220 volt circuit through a 12 - 30 KvA transformer fitted with a variable reactance, the series of taps from the secondary permitting some measure of control over the speed of melting and furnace operation.

This type of furnace has very low operational cost;

Fig. 12. 15 lb. capacity melting furnace with mould in casting position.

its capital cost is of a moderate order and is adaptable to direct pressure or gravity casting. Whilst this proves attractive, it must be realised that small sized melting stock only can be charged owing to the small aperture or throat (1″ diameter) leading into the crucible. Also, there is a certain amount of carbon pick-up and little or no refining can take place on the bath of molten metal prior to pouring. This latter point is partly counterbalanced by the fact that a slightly reducing atmosphere is present while the furnace is operating, thus minimising the loss of certain alloying elements.

It is almost standard practice to feed bars of metal ($\frac{1}{4}$″ - $\frac{1}{2}$″ diameter) of the desired composition, into the furnace. Occasionally, compositions are made up to suit specific requirements but usually materials to standard specifications are employed. The bars are cut into suitable lengths (12″ - 24″ long) and shot blasted in order to remove all traces of grease, rust, paint, etc. Each charge is accurately weighed, especially if the indirect melting furnace coupled with the air pressure method of casting is employed, and introduced into the furnace. As soon as the metal has been melted and super-heated ready for pouring, the casting temperature is measured with a Grace-Schofield type immersion thermocouple. This employs platinum-platinum/rhodium thermocouple wires fixed in a silica sheath. These are attached by means of a compensating lead to a quick-action indicator of suitable design. As soon as the deserved temperature is attained, the deoxidation treatment or necessary additions to the charge are then made.

Casting

There are two main methods employed for pouring investment castings :

(a) gravity casting

(b) air or low pressure casting

Gravity casting is usually practised on reasonably heavy sectioned components whilst the mould is at an elevated temperature. The molten metal can be transferred from the furnace into a carrier-pot and then poured into the mould, or if the furnace can be tilted through 180°, the mould may be clamped in position and poured direct. It is advisable when employing gravity casting to utilise a coarse grade of investment in order to induce maximum permeability into the mould. If the moulds are to be cast at room temperature, this becomes imperative.

Direct air pressure casting is often termed low pressure casting, since air pressures of 3 - 15 lb. per sq. inch are applied behind the molten metal as it enters the mould cavity. The indirect arc furnace is fitted with air inlets which lead into the furnace through the carbon ports. These are connected to an air valve which is attached to the furnace stand and operated by means of a cam when the furnace is inverted through 180°. A similar arrangement can be fitted to the high frequency induction furnace.

Before clamping the mould on to the furnace (Fig. 12) an asbestos gasket is placed between the furnace top-plate and the mould. This locates the mould inlet in relationship to the throat of the furnace and also forms a leak-proof joint, thus taking full advantage of the induced pressure. The pressure on the sprue tip tends to force the metal downwards as it freezes but this is often nullified over the rest of the casting, the thin sections having chilled off very rapidly.

Pressures below 3 lb. are often inadequate to force the metal at a sufficiently high velocity so as to fill the mould cavity completely. Also, mis-run castings will result if there are pressure leakages at the gasket joint or carbon ports, or if the cam fails to operate. Pressures over 15 lb. tend to rupture the mould unless extra support is available in the form of a metal shroud.

Probably the main disadvantages of this method of casting for quantity production lie in the fact that a number of small melting units are required, since each cast completely empties the melting furnace.

Fettling and Inspection

The fettling and finishing operations begin with the removal of the castings from the mould. This is usually carried out when the mould has cooled to room temperature and must be carefully done to minimise distortion.

The investment is removed from the casting by means of vibration and the castings separated from the assembly or cluster by removal of sprues, runners, gates, etc. Band saws, friction saws, abrasive wheels and discs are used for this operation.

Rough castings are ground on wheels or surface belts to remove excess metal at gates, feeders or major flash lines resulting from mould cracks. A preliminary inspection is made to remove all obvious scrap parts resulting from mis-runs, air or gas holes, refractory inclusions, etc. The remainder are finished by machine or hand grinding, polishing, straightening, shot blasting, etc. Finish operations usually include removal of all small metal droplets, attributable to air holes in the investment, fins and small flow lines. Special finish operations may include press straightening or stretching of castings, to eliminate effects of casting stresses or minor distortion in shape due to pattern warpage.

The surface finish of the areas in contact with a good primary coating is as smooth as the surfaces commonly encountered in die castings. The final surface finish is determined by the use of shot blasting, employing the finest grade steel shot, to provide a uniform matt finish to all surfaces of the piece.

The castings are checked for dimensional accuracy and visual defects before being submitted for X-ray examination. All stressed or working parts are given a 100% X-ray check. Other castings are X-rayed in order to develop satisfactory foundry methods and, thereafter, a 10% check is applied. If necessary, the X-ray examination can be supplemented with a hot oil and chalk examination for shrinkage, porosity or crack detection. A selection of castings produced by this process is shown in Fig. 13.

CRITICAL SURVEY OF PROCESS

Precision casting has its limitations as has every other method of production. The ideal component for

casting weighs anything from 1 gm. to 5 lb., has no longer dimension than 10″ and is 0.040″ to 0.25″ thick. Larger castings are being produced but the range quoted offers the greatest degree of accuracy and best economic advantage, since increasing the size of the casting causes the investment process to lose its competitive advantage, i.e., dimensional control.

Like other foundry techniques, precision investment casting is best suited by thin even sections. Rapid changes in section are to be avoided and variations in thickness lead to difficulties in casting methods and dimensional tolerances attainable. This will be appreciated when it is realised that the use of chills or other artifices, as are commonly used in regular foundry practice to promote progressive solidification, are either difficult or impossible to use in the investment casting process. The minimum general wall thickness is considered to be 0.040″, although it is possible to cast to 0.010″ on special shapes and sections as exampled by the airfoil contours of the turbine blade.

Holes can be cast to any desired shape but much depends upon the size and length of the hole, whether it is open both ends, etc. Holes as small as 1/16″ diameter have been cast successfully, but there are limitations on the roundness or accuracy which can be achieved. Therefore, they should be clearance holes only or finished by machining methods. As a general guide, the smaller the diameter of the hole, the shorter should be the length. This is governed by the fragile nature of the refractory material forming the core. Blind holes are difficult to cast and their depth is again governed by their diameter, 1 to 2″ × D being usual. Complex cored passages also offer certain limitations. This is due to the difficulty of designing dies with collapsible cores or the functional operation of them, ensuring that the minimum of distortion occurs on removal from the dispensable pattern. It is possible, in certain cases, to overcome this problem by producing the pattern in separate sections and then joining them together in the normal manner, but some loss in dimensional accuracy and surface finish occurs. Even so, this method is employed for joining multiple assemblies into single units and producing components of high strength, low weight and improved design.

It is not recommended to cast thread contours unless in very special circumstances. There can be problems of accuracy of pitch and it is always cheaper to machine or grind the thread in a subsequent operation. To incorporate threads also increases the injection die costs and rejection rates in the inspection of patterns and the finished casting.

Large flat surfaces are difficult to produce free from internal and external imperfections and the designer should specify which faces and areas must be free from all defects.

The accuracy of the dimensional tolerances to which a casting or even a specific dimension may be held depends upon numerous factors. Firstly, slight variations in injection die temperature can cause some measurable difference in a pattern having a 2″ to 3″ length. Again, variations in pressure and wax injection temperature cause discrepancies to arise, amounting to as much as ± 0.002″ on a 3″ dimension.

Fig. 13. Selection of castings made by the investment casting process.

The ceramic materials from which the mould is made, however uniform in quality, vary slightly in expansion and contraction characteristics, especially when heated to the high temperatures demanded by the process. Also, it is only possible to hold the temperature of the molten metal to within a range of ± 10°C. and this causes some measurable variations in the final dimensions of the casting.

It is difficult to specify any set general tolerance to which castings can be held as the design and shape of the individual part, to a great extent, govern this. In some instances, on small dimensions up to ½″ tolerance of ± 0.002″/″ can be maintained but generally on larger sizes ± 0.005″/″ can be expected on the parts "as cast". Another controversial point is the speed with which a casting can be produced from a print. It is possible for simple castings to be made in a matter of days but for complex parts where close dimensions are specified, the process must be carefully worked out, all variable conditions determined and laid down on a control chart. This is all time-consuming and as the process itself is a 3-4 day cycle, it is obvious that some weeks may elapse before quantity production can commence.

Casting Alloys

By far, the majority of investment castings are produced from the heat resisting, abrasion resisting

TYPE	COMPOSITION										MECHANICAL PROPERTIES			
	C	Si	Ni	Cr	W	Mo	Co	Ti	Nb	Others	0.1% P	U.T.S.	% El.	B.H.N.
Ni-Cr-Ti	0.1	1	74	20	—	—	2	2	—	Al 1	26	45	22	205
Fe-Ni-Cr-Co	0.4	1	13	13	2.5	2	10	—	3	—	18.5	37	10.5	200
Co-Fe-Cr-Ni	0.3	0.5	13	18	—	2	45	—	1.5	V 3	29	34	1.5	310
Fe-Cr-Ni	0.2	1.5	11	23	3	—	—	—	—	—	14.5	36	16	200 to 250
Fe-Cr-Ni	0.4	1	14	14	2.5	—	—	—	—	—	18.5	33	9	200 to 250
Fe-Cr	0.1	1	—	13	—	—	—	—	—	—	27	41	13	214
Fe-Cr-Ni	0.2	1	2	18	—	—	—	—	—	—	39	42	—	470
Fe-Ni-Cr-Mo	0.2	—	1.5	1.75	—	0.6	—	—	—	V 0.25	—	57	4	305

Fig. 14. Composition and properties of steels cast by the investment process.

and stainless steel alloys. The foundry characteristics of all straight carbon steels are decidedly inferior to the special alloy materials. The higher raw metal cost for the alloy is well off-set by the increased yield of good castings and the improved detail and finish of the parts produced. This results in castings that cost less per piece than those made of straight carbon steel.

The most satisfactory ferrous alloy for the investment foundry is the austenitic stainless type. It is the most fluid, least subject to change in composition during melting, least subject to gassing and entirely passive in contact with the majority of the refractory materials employed for the primary coating of the dispensable pattern. There are, in fact, few applications where the straight carbon steels are justifiably employed. Their poor fluidity, high chemical activity and gassiness result in the production of comparatively unstable and inaccurate castings.

Another factor which must be mentioned when using steels dependent upon carbon to produce good physical properties, is the decarburised layer of the surface of the casting. This layer may vary between 0.005" to 0.020" in depth, depending upon the time the casting remains at elevated temperatures. There are several ways of eliminating or minimising this problem. The first is to reduce the mould temperature prior to pouring the metal. After heating the mould to 1000°C, it is allowed to cool slowly to 300-500°C. thus chilling the casting at a faster rate. The second method is to inject an inert gas e.g., nitrogen, just prior to the pouring operation. Alternatively, the decarburised layer may be restored in a salt bath or some carburising treatment. If the casting is to be machined it is possible that the layer may be removed during that operation.

Typical compositions, together with their physical properties, are given in Fig. 14.

Cost of the Process

In this most important factor, it must be stated that a precision investment casting is more costly to produce than a sand casting. However, it must be compared with a sand casting on which there has been carried out those machining operations necessary to meet requirements. Also, the process is not a competitive method for making parts which can be readily machined. This will be appreciated when it is realised that as many as 40 hand operations are necessary to produce an investment casting.

Whereas sand castings usually are sold on a weight basis, investment castings are best sold as finished pieces, since a small part may be much more costly than a less intricate large part.

The tooling costs for this process can be exceedingly small for some components and this remains one of the most attractive features. Quite often, on small components a few pounds will cover the die cost whilst hundreds of pounds may be necessary for jigs, etc., if produced by machining methods.

Applications for Investment Castings

The fields of application for the investment casting process may be summarised as follows :-

1. large quantity production of small parts where the alloys employed are unusually difficult to machine, forge or hand fabricate;
2. large quantity production of small intricately shaped parts requiring numerous machining operations;
3. large or small quantity production where design changes are apt to be frequent and unstabilised and the time factor is important;
4. for small quantity production where the tooling-up for other methods is too expensive and time-consuming;
5. for large or small quantity production of a number of "fitted components", redesigned as one composite unit to improve efficiency of product;
6. large or small quantity production of special shapes, e.g., airfoil section, difficult to machine because of exterior configuration;
7. production of reasonably large castings where tolerances, thinner section and surface finish better than ordinary sand castings are desirable.

Some fields where investment castings are finding useful and economical applications are :-

(a) gas turbines—stator blades, latches, brackets, jet nozzles, etc.;

(b) chemical engineering—impellors, corrosive valves, refrigerator, corrosive pump parts, oil production components, etc.;

(c) metal dies—either complete or in the form of inserts for plastic, rubber or ceramic moulding or die castings;

(d) general engineering—surgical implements, textile and sewing machine spinerettes and feeders, ordnance parts, instrument cams and gears, dairy equipment, etc.

Having discussed the various fields of applications for investment castings together with typical examples, it must be emphasised that where the process can be used to particular advantage is in the elimination of numerous machining operations. Quite often it is wise policy to cast 90-95% of the desired finished shape and leave all critical dimensions to be included as a final machining operation. This leads to success and economy. Trying to produce the casting to finished requirements often leads to failure. This will be realised if finished tolerances call for accuracies within $\pm$ .001" on any dimension or $\pm$ 0.002" to $\pm$ 0.004" over a considerable length. These figures cannot be held in any casting over all dimensions under production conditions.

Future Outlook

As will be realised, investment casting is a specialised process requiring specialised equipment, the handling and formulating of materials not normally used in foundries, and constant scientific supervision.

Equipment is now available which has been specially designed for the process and this will lead to some improvements as its trial and acceptance become standardised.

With regard to investment materials, much has been learned during the past few years and the necessary basic requisites, e.g., grading, structure and composition, are recognised. Also, the use of water-base bonding media, so long sought by the investment founder, is now being universally used. This latter point has, from an economic view, brought the process into the realms of the competitive market, and will have considerable influence on the development of the industry as a whole. It will allow the process to grow from being regarded as an interesting "laboratory experiment" into a real production force.

One of the prime requisites necessary for the further advancement of the process is a really strong expendable pattern material as an alternative to the commonly employed wax. Such a material would allow many alternatives and economies to be effected during the moulding operation.

With regard to the materials cast by this process, much fundamental work is necessary in order to find the alloys producing the best physical properties when cast into moulds which are at elevated temperatures. The question of their suitability for subsequent surface hardening treatments must be borne in mind, since some components require high surface hardness. Also, cast materials having fatigue values as high as comparative wrought materials are needed, especially for the high duty service to which some castings may be subject. With these problems solved, the applications available to the investment casting process would be further increased and its value to the engineer enhanced.

In conclusion, the Author wishes to thank the Directors of the Bristol Aeroplane Company for permission to present this Paper.

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MACHINE TOOLS FOR PRECISION WORK IN THE CLOCK AND WATCH INDUSTRY

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Presented at a Joint Meeting of the West Wales Section of the Institution of Production Engineers and the British Horological Institute, at Swansea, 26th February, 1954.

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Mr. Matthews

THE problems confronting the horological engineer differ from those of the production engineer by virtue only of the very small components used. If we consider that within a compass of approximately 1″ diameter an overall gear ratio of about 4,000 to 1 is required, it will be appreciated that somewhere or other very small wheels and pinions must be used. Also, quite an ordinary watch during 24 hours is accurate to within 0.03 per cent (this is assuming an accuracy of ½ minute a day). The low power available necessitates the use of small pivots (these may be 0.10 mm. or 0.004″ diameter) and the necessary reduction of friction. This can only be brought about by having an extremely high finish on the pivots and a good bearing surface on the hole, normally a jewel.

When we consider that the watch and clock repairer replaces broken or missing parts without the aid of drawings or set tolerances, we should readily appreciate the extreme accuracy and touch with which he works.

An appreciation of these small components may be gained by reference to Fig. 1, which indicates the form and dimensions of a typical watch pinion.

These components are turned on a sliding headstock automatic lathe similar to the one shown in Fig. 2.

This type of machine is universally used for the turning of watch components, which are turned quite easily to tolerances of 0.01 mm. (.0003″). This accuracy, however, is dependent mainly on the accuracy of material and guide bush. Turning, recessing, parting, drilling, tapping and the slotting of screw heads are normal operations done without changing the speed of revolution of the headstock. It is usual on a machine of this description to turn rather than form, minimising wherever possible deflections due to cutting forces on the slender turned

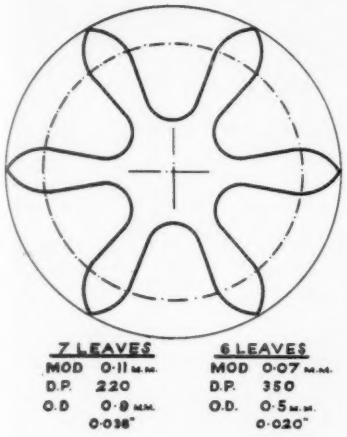


Fig. 1. Form and dimensions of a typical watch pinion.

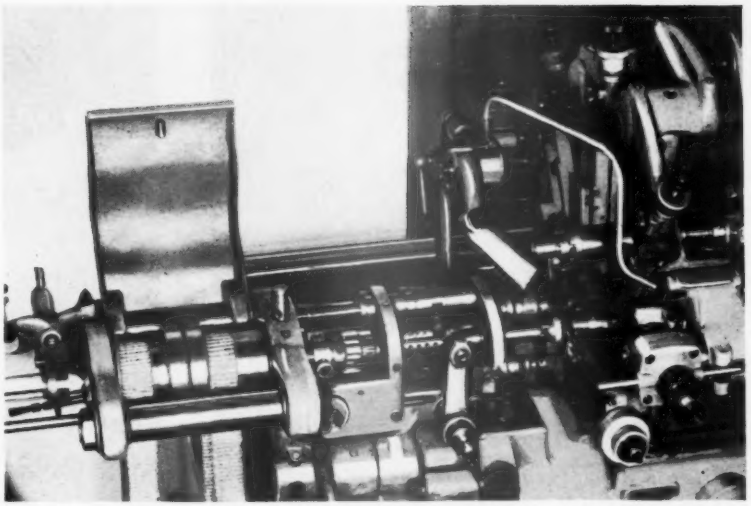


Fig. 2. Sliding headstock automatic lathe used for turning watch components.

parts. All the tools are set as closely as possible to the collet, the bar being fed forward continuously.

The turned pinion is then transferred for gear cutting to a special type of milling machine shown in Fig. 3.

This machine, which may be fully automatic, uses two cutters, one cutter being set to two-thirds the depth and the other for finishing. It is an index type of machine, requiring for different components only cutters, index and pusher plates. The method of holding these components may be seen in Fig. 4. A hexagonal form of serration is punched into the driving centre, which has previously been conically centred. These serrations grip the male cone on the pinion blank and provide the only form of driving dog possible for such small diameters. Concentricity of the serrations is naturally of great importance and is difficult to attain.

After this operation, the pinion is hardened and tempered. The primary function of this heat treatment and constant hardness is merely to ascertain that on subsequent polishing and burnishing operations, a regular high finish may be obtained. Even the machine for checking the diamond hardness number is of a delicate character, applying loads between 50 and 1,000 grams (Fig. 5). The general principle and operation of this machine is otherwise similar to larger and more conventional types.

The polishing of the pinion leaves is an operation which, although appearing crude, has for a considerable number of years proved quite satisfactory. The machine is illustrated in Fig. 6.

The wooden wheel, having been turned to a narrow edge, has a helix struck by a graver on its periphery. This is brought to bear on a hardened pinion supported on a carriage which oscillates axially. The pinion should revolve due to the helix, the form of the pinion tooth being impressed on the wheel, which is then set to correct depth, the stroke adjusted and an abrasive added to it. Successive pinions can then be polished, the average time per pinion being in the region of five seconds.

Fig. 3. Special type of milling machine.

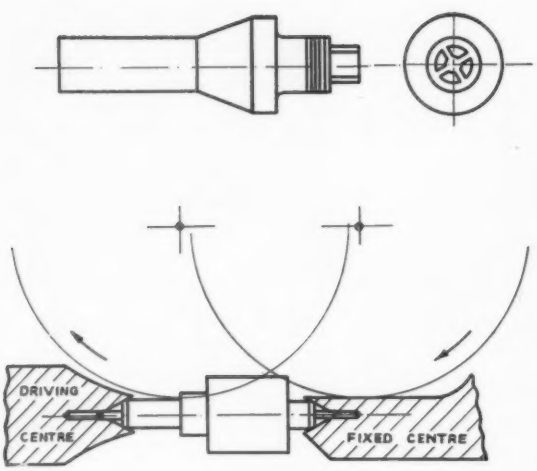


Fig. 4. Method of holding components in milling machine.

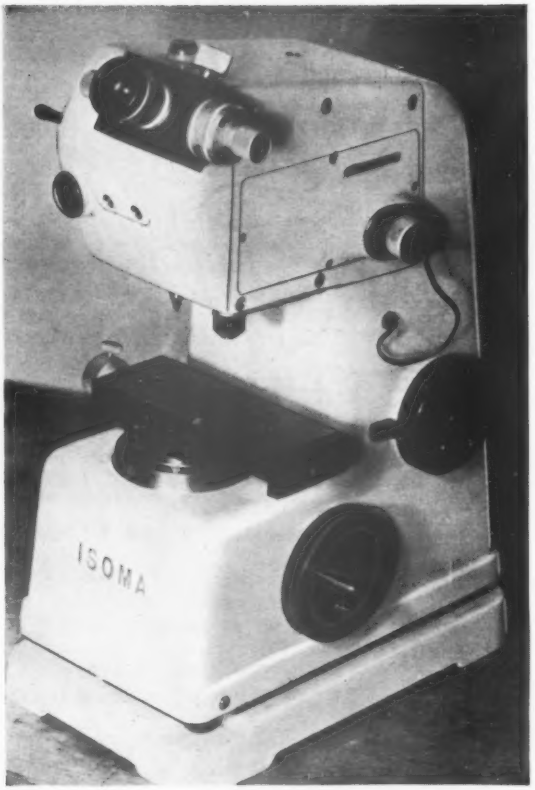


Fig. 5. Machine for checking diamond hardness.

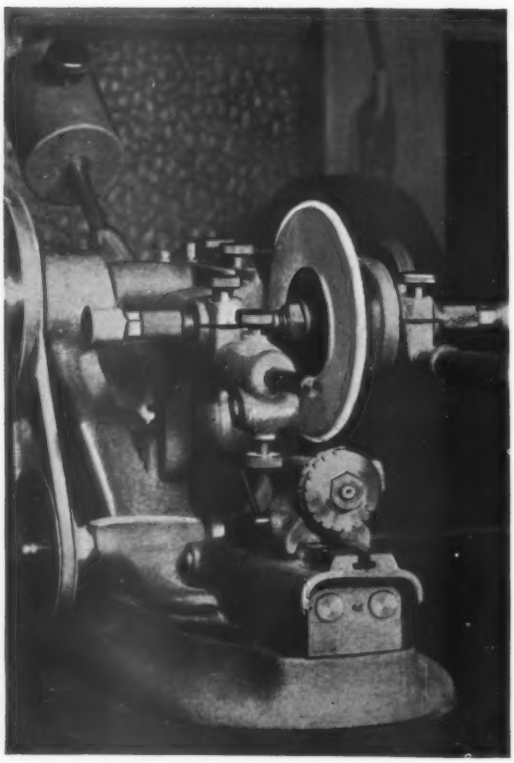
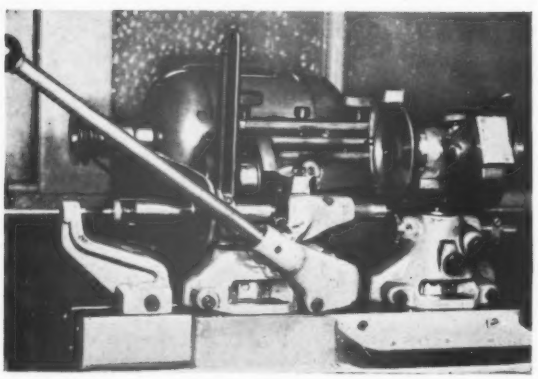


Fig. 6. Polishing the pinion leaves.

Fig. 7. *(below)* Burnishing machine for pivots and ends of pinion leaves.



The pivots and ends of the pinion leaves are finished on a burnishing machine illustrated in Fig. 7. A rotating wheel of tungsten carbide is brought into contact with the rotating pivot and the amount of material removed is 0.01 mm. (.0004″); if too much material is left for removal the pivot may be work hardened. This may well account for the considerable number of pivot breakages which occur in watches On the burnishing machine the pivots are driven at 1500 revolutions per minute, but as the diameter is perhaps only .005″ (.12 mm.) the surface speed is very small. The resultant cutting speed would be about 350 feet per minute. The cutting edges of the carbide disc may be reground and grained by a diamond impregnated wheel.

The overall length of the pinion may be determined by grinding simultaneously the two ends of the pivot on the smaller grinder shown in Fig. 8; another machine is employed for doming the ends of the pivots.

Watch plates and bridges are usually pressed out from brass strip having a thickness tolerance of about 0.03 mm. (approx. 0.001″). The location holes in the plate are then pointed or centred by a press tool, jig drilled and then shaved to size by another press tool; these three holes are the location points for all subsequent operations. Approximately 60 holes are then pointed on a further press tool and the plate is transferred to an automatic drilling machine —Fig. 9—on which it will be seen that 10 turrets are employed. Due to the speed of the drills, which is 10,000 r.p.m., and to stop overheating of the spindle, the machine is so designed that only the drill actually in use is revolved by a friction drive from the motor. Each drill of a given size will remain in position until all the holes of that size are completed; if a drill breaks an automatic cut-out stops the machine and switches on a warning light. The previously pointed holes are brought on centre in turn by the two circles of cam pins set in a disc at the base. The work holding plate is located on two radius arms, being rigidly fixed to one arm and pivoted on the other. At their other ends the arms are pivoted on slides which move on vertical guides, the relative heights of the slides being controlled by the lengths of the cam pins. The disc is indexed for each hole drilled, the slides being lifted clear by a hydraulic mechanism. In this way any point on the work can be brought opposite the operating drill. It is possible to drill sixty holes per minute. A tapping version of the machine is also available.

The recesses in a plate are milled on a special machine which normally machines two plates at a time in approximately 70 seconds. Tungsten carbide cutters are invariably used. Due to all this pressing and machining, stress relieving of the plates and bridges is essential. It should be noted that not all plates and bridges are drilled in the above manner; quite a number are pierced and then repassed, the repassing tool in this case being a shaving press tool.

The press tools used are invariably two pillar die sets; these ensure a greater concentricity when placed on the press. Also in the case of blanking and piercing, compound rather than follow-on tools are used.

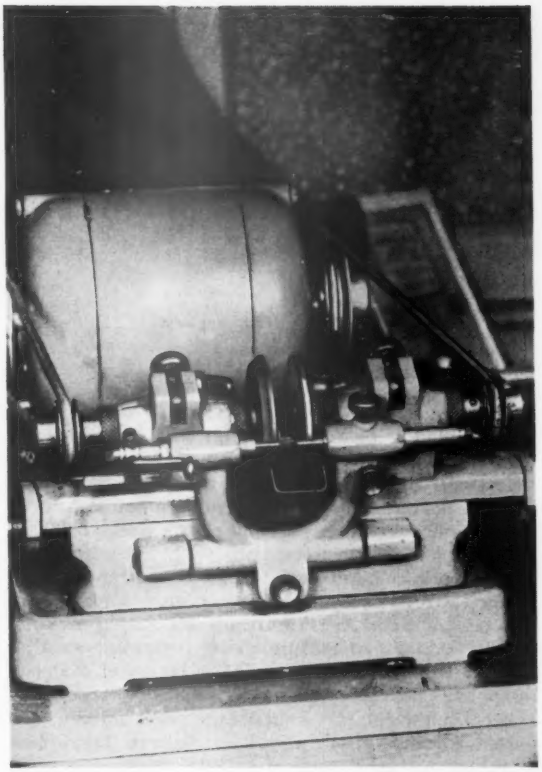
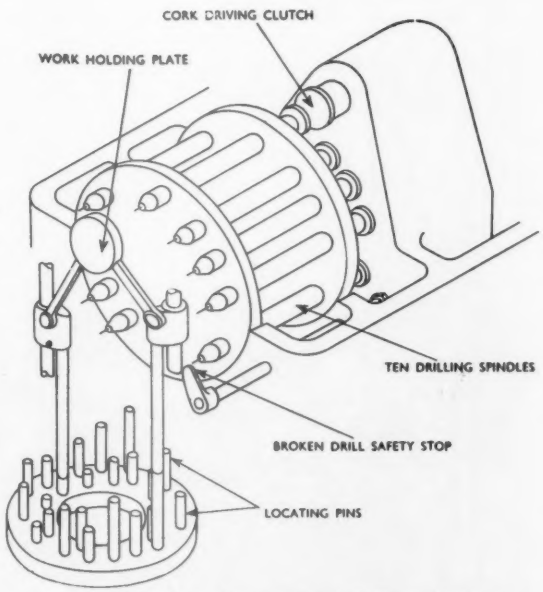


Fig. 8. The two ends of the pivot are ground simultaneously.



Principle of an Automatic Drilling Machine

Fig. 9.

(Courtesy of the Institution of Mechanical Engineers).

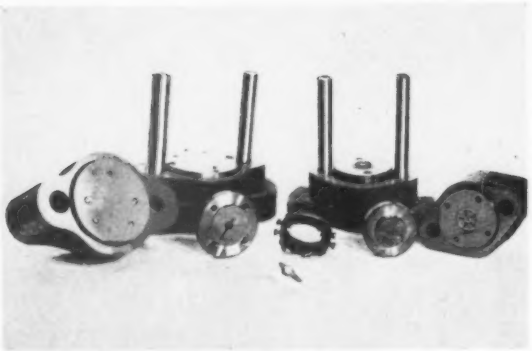


Fig. 10. Special tools and dies.

It will readily be seen that, on small components, it is essential to ensure equal spacing on the pierced holes with the blank. If follow-on tools were used in three or four stages, errors would be bound to arise at each successive stage; these errors could be quite appreciable. Quite a number of components, such as the work holes in a plate and the perimeter of a bridge, are repassed after piercing and blanking. In the case of blanking this means accurately locating the blank in a nest and punching it through another die smaller than the first. The amount of material removed is normally 0.1 mm. (.004″). This operation is called shaving; the components are sometimes repassed through another smaller die and burnished. With normal press tools it is usual to leave a total clearance of between 4% and 7% of the thickness of the strip material between the punch and die. Due to the very thin materials used in watchmaking these figures are sometimes very hard to maintain.

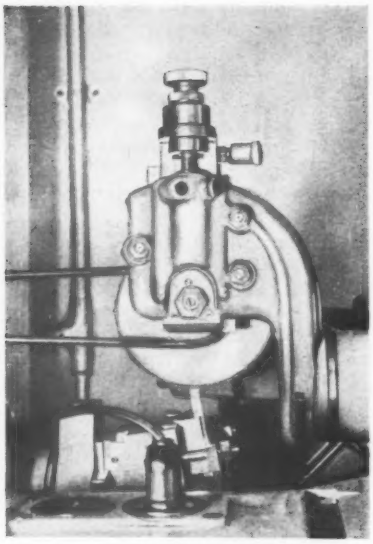


Fig. 11. Profile grinder.

Therefore it is quite common to make the punch an interference fit with the die. The manufacture of these dies and punches may cause considerable worry. One method commonly practised is to manufacture the punch to the shape of the component and, after heat treatment, to drive it gradually through a previously roughed out die which is still in an annealed state.

With the advent of the profile grinder, however, the die may be made after heat treatment. It is split up into two or more segments, each segment being

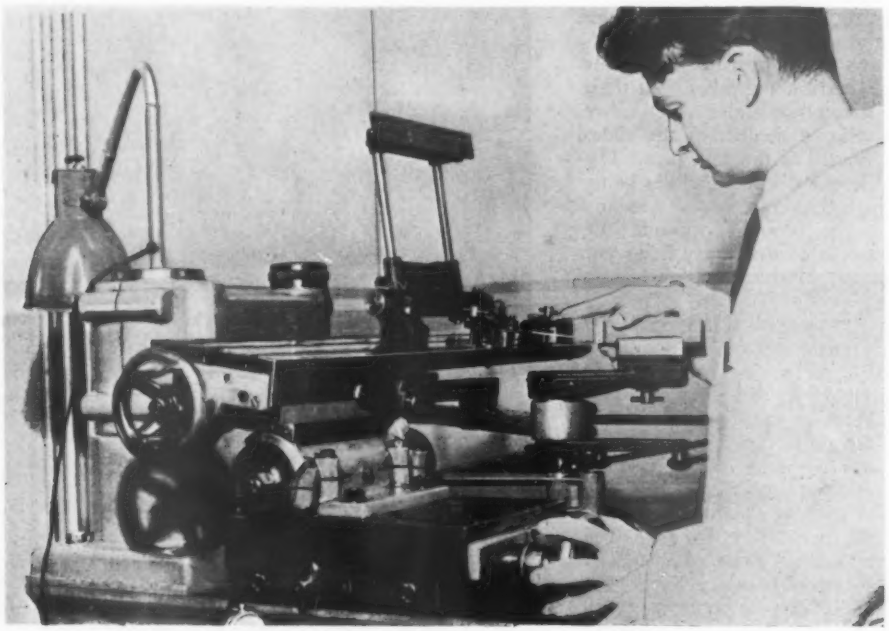


Fig. 12. Profile grinder.

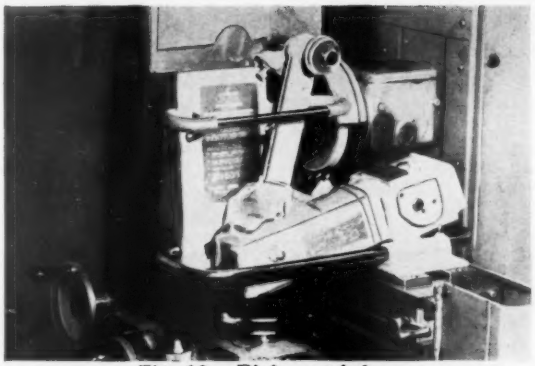


Fig. 13. Diaform grinder.

ground individually to a template. The ground segments are then held together in a cage, the whole die is then shellaced or soldered to a face plate and the periphery is ground to fit a holder.

In Fig. 10, the tools in the die set on the left are for repassing the work holes which provide the location for subsequent operations on a watch plate. The set on the right contains a compound tool for stamping wheel blanks, while in front are typical segmented dies with the cage used for location during manufacture.

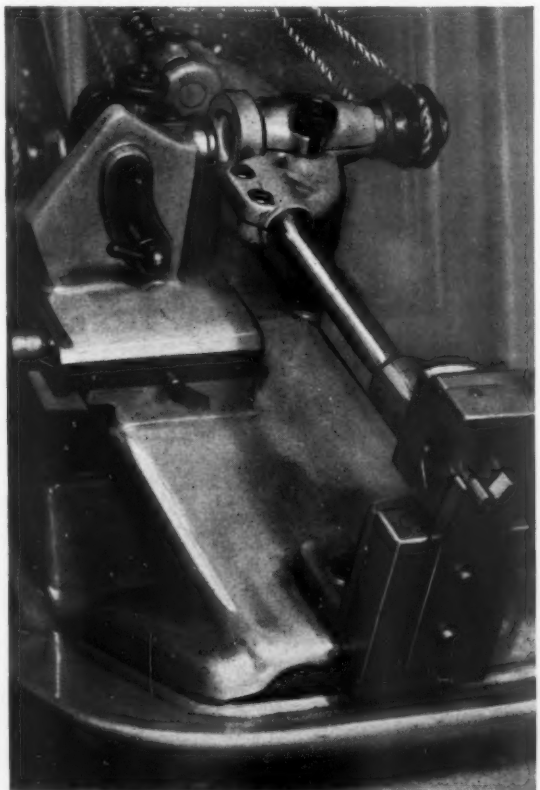


Fig. 14. Special machine for making form tools *(see also* Figs. 15 *and* 16*).*

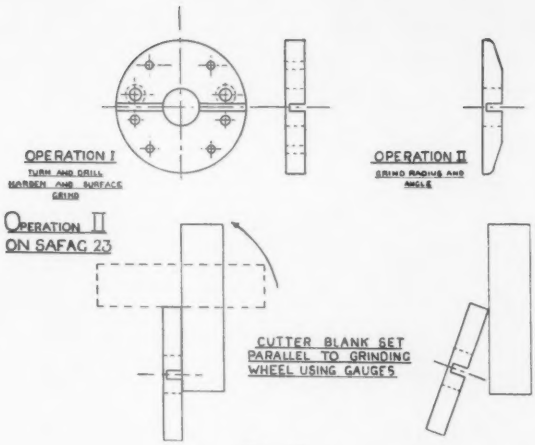


Fig. 15.

Having finished the die the punch may also be made in a like manner. It is sometimes considered preferable to make the punch in an annealed state slightly larger than its finished size and then shave it with the die.

The profile grinder illustrated in Figs. 11 and 12 grinds by generation, an adjustable pantograph mechanism linking the grinding wheel to the form template. The ratio of the pantograph is adjustable between 1 to 1 and 100 to 1 and the metal template has to be profiled to the form required at a suitable magnification. Slip gauges are used for setting the pantograph and the proportional form of the template follower is produced on the wheel by a diamond. It is possible by indexing the component to grind completely through 360 degrees.

The diaform grinder shown in Fig. 13 has a fixed ratio of 10 : 1 and grinds at a maximum through 180 degrees. The grinding wheel is formed to the shape of the template, the work placed on the magnetic chuck or jig of any type of grinding machine, and then ground.

Dies and punches may also be ground by crush grinding. If a die plate having a considerable number of holes in it tends to distort during hardening, this may be overcome by leaving the holes small and then, after heat treatment, grinding them on a jig grinding machine. If this is not possible these undersized holes may be plugged with steel or brass and recentred on the jig borer. When the work is transferred to the lathe, the holes are centred individually, the plugs drilled out and the holes ground. The grinding wheels for small holes, which may be as small as 1 mm. or .04″ diameter, are made of silver steel charged with a suitable abrasive.

The manufacture of form tools for relieving single row cutters and hobs having very small modules usually requires special machine tools. Cycloidal gearing is used in clocks and watches and the form of pinion has a radial dedendum with a circular arc form of addendum.

The machine shown in Fig. 14 takes a prepared blank of the form shown in Fig. 15—Operation I—

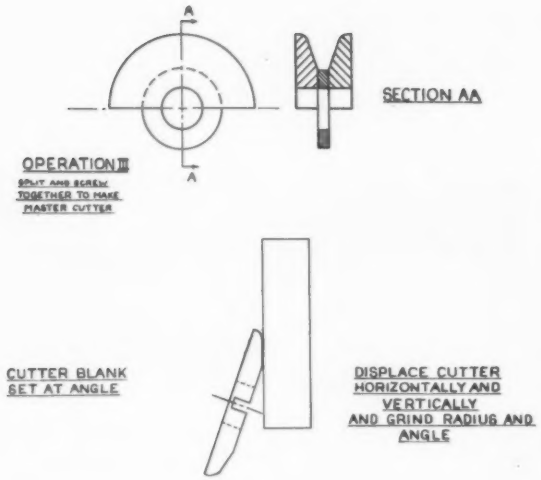

A
SECTION AA
A
OPERATION III
SPLIT AND SCREW TOGETHER TO MAKE MASTER CUTTER
CUTTER BLANK SET AT ANGLE
DISPLACE CUTTER HORIZONTALLY AND VERTICALLY AND GRIND RADIUS AND ANGLE

Fig. 16.

and, after determination of the addendum and flank angle, one side of the blank only is ground. It is then split and the two halves held together, having between them a piece of material equal to the thickness of the tooth at its root, as illustrated in Fig. 16 —Operation III. This female cutter will now produce male cutters which in turn are used as relieving and forming cutters. These tools may also be made on the profile grinders previously shown. The cutters mentioned, however, are of constant profile and maintain their form when reground.

Escape wheels are cut on a special milling machine using five or six different shaped cutters. These are usually just gashed tooth cutters having approximately 80 teeth on the cutter of 20 mm. diameter; typical cutters are shown in Fig. 17.

These may be made on a machine in a total time of about 10 minutes each and are not reground but are discarded on blunting. The machine, shown in Fig. 18, is operated by cams and the cutter used for cutting the blanks resembles a dentist's burr. The blank is moved horizontally and the burr cutter vertically and eccentrically. The cam design and production is very simple and due to the important fact

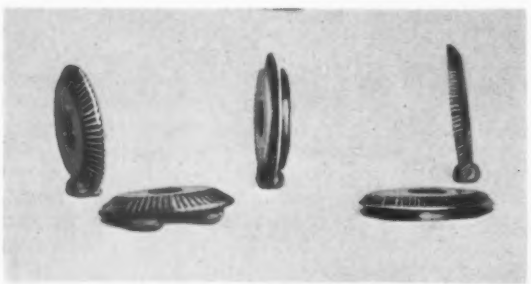


Fig. 17. Typical cutters for escape wheels.

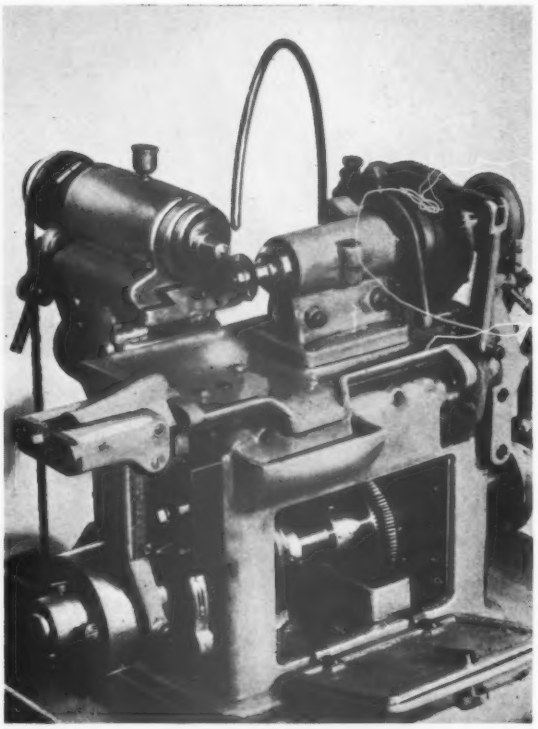


Fig. 18. Cam-operated machine for making cutter blanks.

that movement ratios between 1 :1 and 10 :1 may be obtained from each cam, one set of cams can easily be made to make cutters of different forms. The method of adjusting the fulcrum position of horizontal slide lever can be clearly seen in Fig. 18. Almost any profile of cutter can be produced on this machine.

The cam milling machine shown in Fig. 19 is used for marking out, roughing, finishing and inspecting plate type cams. Once the cam has been designed, it is possible to finish a cam without the old trouble of calculating leads and gears required for each rise or fall. The finishing cuts are taken around the periphery of the cam in the direction which will be taken by the stylus or follower. A circular movement of the headstock spindle gives a linear movement of the slide bar which controls the tool slide. Assuming that a fall on the cam of .250″ through a 30° angle is required, the spindle is first set by means of stops to move through a 30° angle of rotation. The machine is now set to cut a constant velocity curve. It is found that the inspection of a cam on the same mandrel on which it has been manufactured gives the most satisfactory results.

Referring to Fig.19, in which a perspex cam is shown mounted for demonstration, the bar seen in the foreground, parallel to the machine axis, is the slide bar which can be set and locked at an appropriate angle. When this is done, rotation of the work

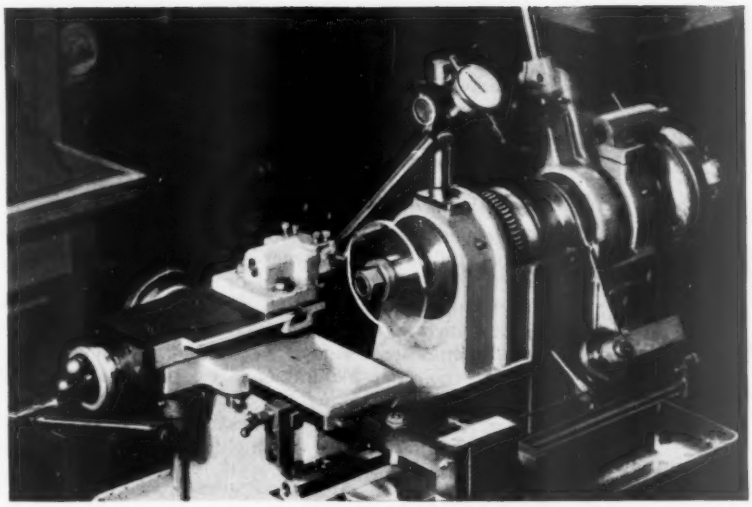


Fig. 19. Cam milling machine for marking out, roughing, finishing and inspecting plate type cams.

spindle moves the bar and causes the tool slide to move towards the machine axis. The required fall of .250" is easily set on the tool slide micrometer and this controls the setting of the slide bar angle.

Cutting Speeds, Tool Angles and Tool Life

Due to the small diameters normally turned and the small drills used, the maximum number of revolutions per minute obtained by calculation of

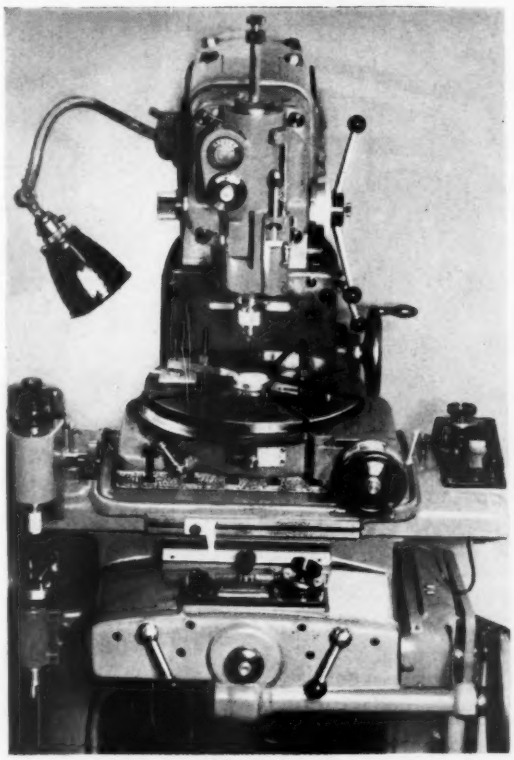


Fig. 20. Jig borer.

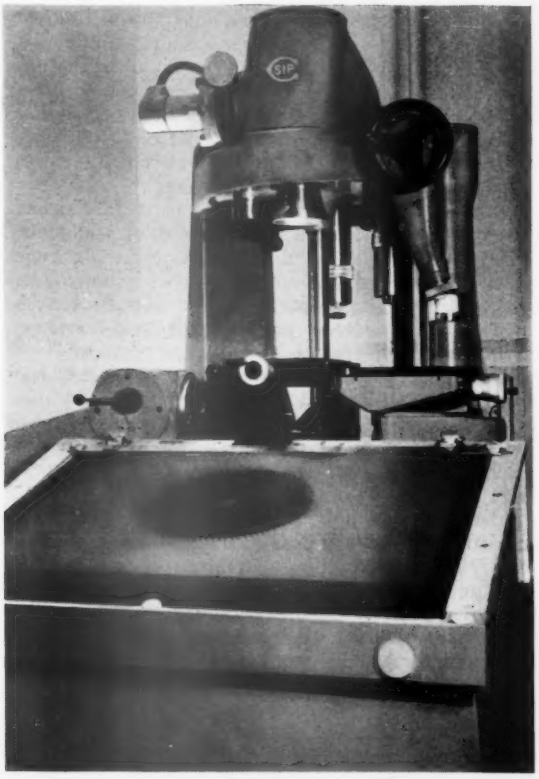


Fig. 21. Projector used to inspect contours.

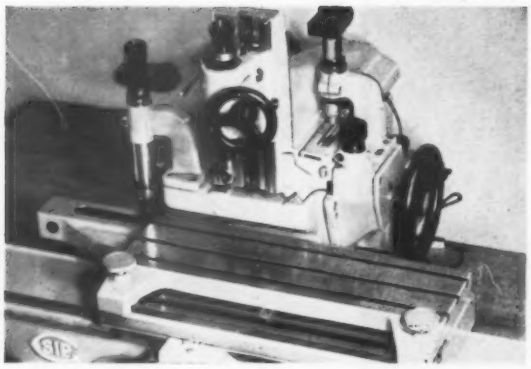


Fig. 22. Universal measuring machine.

cutting speed is not always obtainable in practice. For example, using a .010″ diameter high speed drill, cutting brass, a usual cutting speed would be approximately 150 ft. per minute. This drill could therefore revolve at 60,000 r.p.m. and these conditions would, of course, also prevail for turning and milling.

It will, therefore, be seen that the horological production engineer is interested in tool life rather than in reducing the time per component. A production engineer concerned with more normal components, although very interested in tool life, would probably use carbide tools to reduce machining time. The horologist also finds that, on a lot of machining operations, excessive clearance angles on the cutting tools are necessary, due in the majority of cases to the machine design. Generally, of course, the rake and clearance angles follow very closely those used by the ordinary production engineer.

The inspection of finished components follows very closely the methods used in other fields of production. Instruments such as micrometers (normally with specially designed non-rotating anvils), comparators and taper wire gauges for hole determination may be used. The inspection of the tools used, however, particularly form tools, is of major importance.

The jig borer shown in Fig. 20 has corrected lead screws and is calibrated to an accuracy of .001 mm. or .000040″. It is very often used as a means of inspecting, apart from its use as a productive machine. It is also capable of repeating operations from a master jig or fixture.

The projector illustrated in Fig. 21, which can give x10, x20, x50 and x100 magnifications, is used mainly for the inspection of contours, although linear measurements may also be obtained by using the micrometer screws on the work stage. Surface illumination is used for the inspection of watches, blind holes, indenting tools, etc.

The Universal Measuring Machine shown in Fig. 22 is independent of lead screws and is controlled by accurately divided steel scales viewed through micrometer microscopes. It will repeat readings to an accuracy of .00004″ quite easily. With experience, readings of .00001″ may be obtained.

Fig. 23 is the same machine set to measure an internal bore with a feeler attachment. It may be safely assumed that with the full accessories which are available on this machine, the inspection of almost any type of component could be carried out.

Conclusion

While special machine tools have been and are still being developed, the practice of normal production engineering is followed and the same principles are applied, except where considerations of size or frailty require an unusual or special treatment.

Quite naturally, some production problems are intensified for these reasons but in other cases the difficulties are lessened. One important factor which has a considerable influence on machine tools and production techniques for small-sized components is that the total forces involved are quite small, even though intensities of cutting force are just as great as in larger work.

Acknowledgment

The Author is indebted to the Board of Governors of the National College of Horology and Instrument Technology for the use of the facilities of the College in the preparation of this Paper.

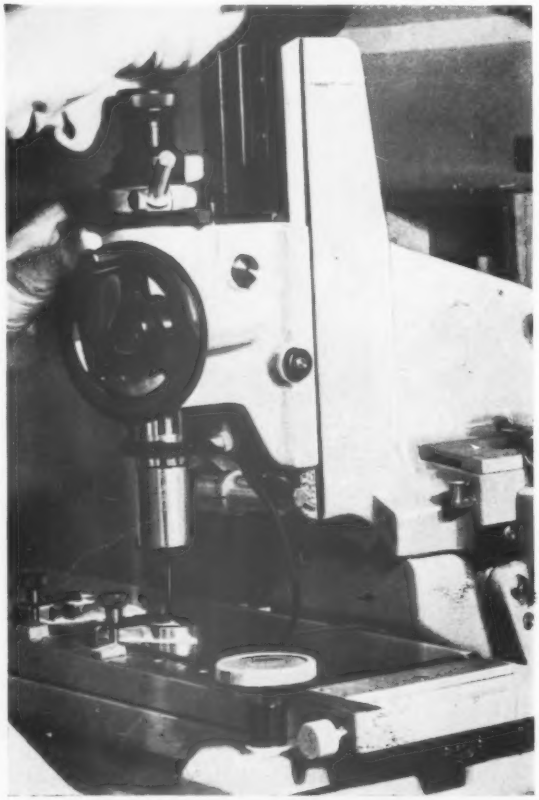


Fig. 23. Universal measuring machine set to measure an internal bore with a feeler attachment.

THE USE OF WORK STUDY BY MANAGEMENT

by R. B. KEMBALL-COOK, M.A., A.M.I.Mech.E., A.M.I.Prod.E.

This Paper is based on an address given to the London Graduate Section Weekend School, 1953.

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He was later appointed a technical officer with the Anti-Submarine Warfare Department of the Admiralty, working on the production of Asdics and Echosounders.

In 1946 he joined Production-Engineering, Limited, management consultants, and is now managing the Training Centre, where courses in Work Study, Management, Accounting and Production Control are held.

Mr. Kemball-Cook

WHEN work study is discussed at conferences, or in articles in the technical press, the emphasis is usually placed on the actual mechanics of work study. Such discussions are essential to its development, since it is probably only in the heat of controversy, fanned by the airing of different opinions, that agreement on such problems as nomenclature, the validity of rating, the assessment of rest factors or the proper place of predetermined motion times can be forged.

Necessary though they are, the debates about the techniques of work study tend to obscure an equally important subject—the use of work study by Management. However interesting work study may be as a subject in itself, it can only justify its existence to the extent that it helps Management to manage.

Even when the discussion does centre round its value to Management, work study is often considered as merely the first step in the installation of an incentive scheme. This, however, is only one of the many applications of work study, and not always the most important.

What, in fact, are the questions which a manager must ask if he is to run his business successfully?

Are the methods as good as we can make them?
What kind of incentive scheme is the best for our type of work?
Are the operators working well?
Are they earning satisfactory bonus?
Are our piece-rates, or allowed times, right?
What production difficulties are arising on the shop floor?
Is output up to programme? If so, is the trend all right too?
Are beginners being trained properly?
Are labour costs right?
Are the indirect workers working well?
Is the costing system accurate and does it tell us the right information?
Are selling prices right?
Can the layout, or the materials handling, be improved?
Is the quality of the work right?

Work study provides the answers to these questions.

Analytical Method

One use of work study that is implicit in any application is the training that is given to its practitioner in the analytical approach to industrial problems of any kind. The methods of work study are based on this approach, which may be summarised as the five following steps :-

recognition of the problem;
collecting the facts;
critical analysis of the facts;
construction of the solution;
installation and maintenance of the solution.

These steps are the basic method of work study itself, and are also our method of attacking problems in the other wider fields discussed later. The collection of facts is vital to the solution of any problem, though too often decisions are based instead on guesswork or personal opinions. Facts are as important to the manager in industry as intelligence is to the commander of any army in war.

Analytical method is not of course the only tool needed by the investigator in industry. Intuition and imaginative thinking are also essential to any original work.

Work Simplification and Process Improvements

Work simplification, which refers to the planning of the movements of an operative and the arrangement of his workplace, and process improvements which refer to the planning of the process as a whole, are such direct results of work study that they are considered as part of the technique itself. However, they are worth listing separately here as perhaps the most important application of work study.

Without discussing in detail the various charting or filming methods of analysis and recording the sequence of movements, nor the application of the principles of motion economy to improving the movements, the following points about the technique of motion study are relevant to its use by Management :-

1. Although it is sometimes necessary to use the detailed techniques of motion analysis and charting to collect all the data, yet most improvements are in fact effected by the engineer who has trained himself first in these techniques and is then able to recognise at a glance the wasteful movements and unsuitable tools.

   If the engineer has accustomed himself to making "Simo" charts, he will have become expert at detecting idle time or wasteful movements; figuratively speaking, he will have developed an allergy to these elements and the sight, for example, of an operative using his hand as a vice will immediately suggest the possibility of using a simple fixture to speed the assembly.

   The more extensive the engineer's experience, the more he will be able to devise improvements "by inspection". The making of formal studies will still, however, be essential for the training of engineers, for checking that the last ounce of improvement has been obtained from the "mass production" jobs and for demonstrating revised methods to operatives, supervision and Management.
2. Time study should not be excluded even when the emphasis in an application is on methods of improvement.

   It is essential to validating an improvement, since without a comparison of the amounts of work in the job before and after the alteration one cannot be sure how much improvement there has been, or even sometimes if there has been any improvement at all. This comparison is not expensive in time; short check studies are sufficient since we do not require the same accuracy as we should for an incentive scheme.
3. A sense of proportion is needed all through study work, whether in the appraisal of the techniques themselves, or in their application in the factory. It is particularly necessary when considering the expense incurred in applying work study. The temptation to make too thorough, and therefore too expensive, an investigation must be resisted. Motion study engineers sometimes talk as though the best way of performing an operation is that which takes the least time; Management, on the other hand, is more interested in its performance at the lowest total cost.

   Improvements can often be made without great expense on new equipment. Thus the provision of simple fixtures or tools, the rearrangement of the shop layout or changing the sequence of operations can often bring a considerable saving in the work content of the jobs. Where expense on new equipment cannot be avoided, it should be carefully balanced against the expected savings.

   No firm rule can be given as to how much work study is justified in investigating any particular operation but some guidance can be given by estimating the expected annual saving as follows :-

   let the expected amount of work saved on each unit of product be S standard minutes (or other convenient unit of work measurement). Let the annual quantity of the product made be Q. Let the labour rate for the job be L shillings per hour. Let the machine hour rate for the job (when a machine is used in the operation) be M shillings per hour. Then the expected annual saving to be obtained by applying work study

$$= S \times Q \times \frac{L + M}{60} \text{ shillings}$$

$$= £ \frac{S \times Q \times (L + M)}{1{,}200}$$

   For example, if a shirt factory makes 100,000 dozen shirts each year, and the work study engineer expects to save ten standard minutes on each dozen shirts, as a result of a work study investigation of an operation

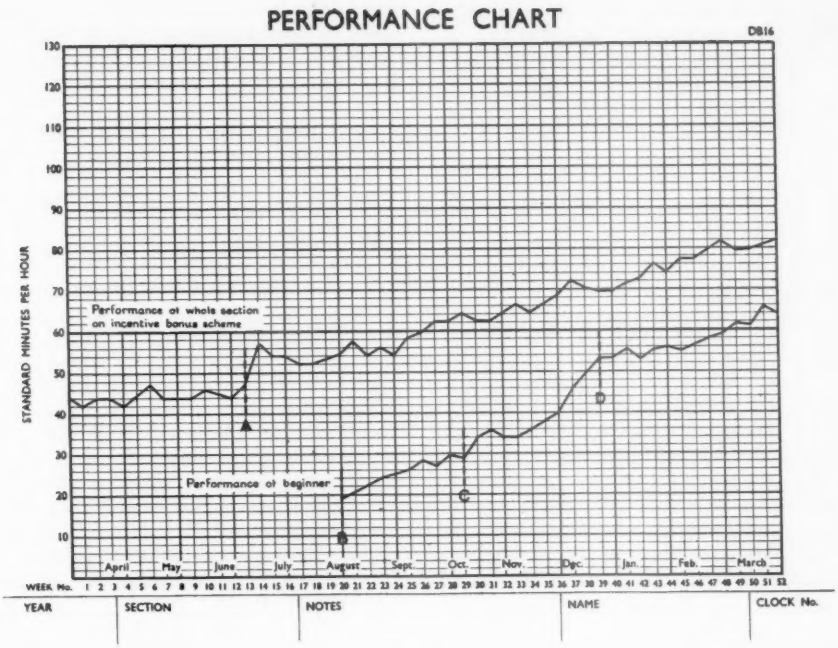

Fig. 1.

Performance of whole section on incentive scheme.

A. Start of incentive scheme.

Performance of beginner.

B. Started in training centre.
C. Started earning bonus on learner's allowance.
D. Transferred to main department.

where the labour rate is 2/6d per hour and the machine rate is 6d hourly, then the expected annual saving will be

$$£\frac{10 \times 100{,}000 \times (2\frac{1}{2} + \frac{1}{2})}{1{,}200} = £2{,}500$$

The development of a more general rule, based on the reasoning above, is given in the Appendix.

In estimating the possible savings that can be set off against the cost of making the methods improvements, it is wise to base them on one year's production only, unless it is certain that the process in question will continue unchanged for a longer period.

Setting Standards of Performance and Providing Control Information

This is perhaps the most important use of work study. It is less obvious than methods improvements, less publicised than incentive schemes, but to a manager who wishes to raise the operating standards of his factory from mediocre to excellent it is vital. Every intelligent agent, whether adult, child or a factory, lives in relation to its standards of performance; in fact, we judge a man by the standards he sets himself and by his success in attaining his standards. Setting standards of performance and measuring success against the standards are two of the essential responsibilities of management and should be exercised at all levels, staff and workers, of the organisation.

With good leadership, employees will work more happily at a high standard than at a low standard: as striking evidence of this, one sometimes sees two factories, on similar work, in the same district, the only difference being the effective and businesslike atmosphere in the one and a much lazier atmosphere in the other. Analysis of the costs shows how expensive a 'lazy atmosphere' can be.

At some levels of the organisation, and even in some factory departments, the standards must be set, and results assessed in terms of personal judgments, but for direct workers on the floor the work study units provide a direct standard by which to measure output. Thus the accepted standard for workers who have a well-designed incentive scheme and a good shop organisation is 80 units per hour.

In contrast, day workers in the same shop might produce at 60, owing to the lack of incentive on output. If, in addition to the lack of incentive, the shop organisation is weak so that skilled operatives are kept waiting for work and are expected to marshal their own tools and materials and to rectify faulty materials, then output may be as low as 40.

Figure 1 shows how the performance of either a

LABOUR SUMMARY

QUARTER ENDING 8th MAY, 1954

DEPARTMENT : MACHINE SHOP

WEEK ENDED	PERFORMANCE OF DIRECT WORKERS										ANALYSIS OF HOURS LOST BY DIRECT WORKERS											
											WAITING TIME					EXCESS ALLOWANCES					TOTAL LOSS	
	Hours Attended	Output in Standard Minutes	Performance S.Ms./Hr.	BASE WAGES £	s.	d.	BONUS £	s.	d.	Bonus %	Waiting for Material	Waiting for Machine	Waiting for Work	Waiting for Inspection	Miscellaneous	Material	Machine or Tools	Learning	Below Standard	Overtime and Miscellaneous	Hours	£
	1	2	3		4			5		6	7	8	9	10	11	12	13	14	15	16	17	18
BUDGET	1480	115,000	78							33												
Feb. 13	1505	99,320	66	188	14	5	43	12	6	23	6	14	120	15	—	4	8	42	80	3	292	37
Feb. 20	1520	103,340	68	191	4	6	47	15	7	25	10	—	132	4	6	3	6	36	60	2	259	32
Feb. 27	1460	102,220	70	182	15	4	51	1	3	28	40	18	73	3	—	10	14	31	43	—	232	29
Mar. 6	1502	109,622	73	189	1	0	55	0	4	29	10	—	35	—	8	25	3	28	24	11	144	18
Mar. 13	1510	104,186	69	188	10	4	56	15	2	30	7	6	15	6	4	80	2	26	19	5	170	21
Mar. 20	1530	111,725	73	191	3	2	59	5	0	31	10	20	6	4	—	5	3	23	21	6	98	12
Mar. 27	1500	117,250	78	187	15	2	61	19	2	33	30	12	4	5	—	10	4	20	11	8	104	13
TOTAL																						

WEEK ENDED	PERFORMANCE OF INDIRECT WORKERS										PAYROLL												COST PER 1000 DIRECT S.Ms. (Shillings)			
																							DIRECT COST			
	Hours Attended	Indirect Standard Minutes	Indirect S.Ms./Hr.	BASE WAGES £	s.	d.	BONUS £	s.	d.	Bonus %	DIRECT WAGES £	s.	d.	INDIRECT WAGES £	s.	d.	MISCELL-ANEOUS WAGES £	s.	d.	TOTAL £	s.	d.	Standard	Actual	Excess over Standard	Indirect and Miscellaneous Cost
	19	20	21	22			23			24	25			26			27			28			29	30	31	32
BUDGET	122	9,200	75																					42·7		4·9
Feb. 13	130	7,946	61	16	5	1	1	19	0	12	232	6	11	18	4	1	8	0	0	258	11	0	41·6	46·8	5·2	5·3
Feb. 20	128	8,266	64	16	2	1	2	18	0	18	239	0	1	19	0	1	8	0	0	266	0	2	42·0	46·4	4·4	5·2
Feb. 27	127	8,176	64	16	0	6	2	18	6	18	233	16	7	18	19	0	7	10	0	260	5	7	41·8	45·6	3·8	5·2
Mar. 6	141	8,770	62	17	12	4	2	13	0	15	244	1	4	20	5	4	8	0	0	272	6	8	42·0	44·6	2·6	5·1
Mar. 13	136	8,335	61	17	0	4	3	4	8	19	245	5	6	20	5	0	8	15	0	274	5	6	41·6	47·1	5·5	5·6
Mar. 20	137	8,938	65	17	3	1	4	5	9	25	250	8	2	21	8	10	8	0	0	279	17	0	41·6	44·9	3·3	5·3
Mar. 27	135	9,380	70	16	19	6	5	1	10	30	249	14	4	22	1	4	8	0	0	279	15	8	41·6	42·6	1·0	5·1
TOTAL																										

Fig. 2.
(see notes at foot of facing page 691)

whole department or an individual operative can be charted week by week to give a clear record of the progress made in improving the standard of performance during a year's working. The upper line records the improvement in the average performance of a group of operatives, showing the initial jump when they started an incentive bonus scheme, and then a more gradual increase as the shop organisation, supervision and training improved. The slight drop after the first jump is an interesting feature which is often observed during the application of an incentive—it is due to the evaporation of the operatives' first interest and curiosity in the new method. The subsequent recovery is due to their gradual practice and experience in working more diligently. The lower line is a record of a beginner's progress in a skilled job.

Other standards derived from work study are those relating to costs. Managements must always make certain assumptions about their total expenditure on labour, and about their product costs, when planning future operations and fixing selling prices; it is valuable to check the fulfilment of these assumptions by calculating the corresponding cost per standard minute and using this as a standard of performance for each operating department. This method of checking actual against standard costs is extended to overheads and materials when a complete system of standard costing is introduced.

It is, of course, no use setting standards unless frequent checks are made of actual performance against the standard, and some form of regular return from each department is needed to enable Management to control it. In Figure 2 is given a simple weekly control return showing each week the total output, the average worker's performance in standard minutes per hour, the percentage bonus earned, an analysis of all waiting time and delay allowances and the cost per standard minute.

The advantages of this return are:-

1. Results for successive weeks are entered one below the other so that Management can see, not only shortcomings in output, performance or cost, but also adverse trends even before they become serious. These trends may be very significant, but would not be easy for Management to perceive by examining one week on its own. Early action can therefore be taken to correct faulty supervision or shop organisation.
2. Since the standards are expressed in terms of work study units, comparisons can be made between different departments and are then unaffected by changes in the types of product manufactured. This independent comparison is also valuable in comparing factories, producing similar products under different conditions, since the work study technique makes an assessment of the effect of the different conditions.
3. The detailed analysis of the waiting time and the excess allowances gives a precise indication of any faults in shop organisation, so that Management can take the specific action needed to correct the fault and can subsequently check whether the action has been effective. Thus excessive hours in the column "waiting for orders" would indicate that the production planning methods should be checked. If in the column "below standard working", they would indicate that there was insufficient incentive, or that more attention should be paid to operatives' training.
4. The control return can be prepared after the end of the week in question and is thus comparable to the intelligence reports which enable a general to fight a battle, rather than to the history written after the war is over. If the week closes on Friday, the return can be on the Manager's desk on Wednesday or even earlier and can be discussed with the shop superintendents and foremen concerned while the week's working is still fresh in their minds, and troubles can be cured before much damage is done.

Fig. 2.

Notes on the Labour Summary

(i) Performance of Direct Workers. Output has increased steadily, except for the week ended 13th March, when there was a drop due to a sudden rise in the hours lost in 'allowances for material'. This trouble was cured by the next week, and the increase continued until the budget output was attained in the last week. The average performance has risen correspondingly from 66 to 78.

(ii) Analysis of Lost Hours. At the start of the period, the most serious causes of lost hours were 'waiting for work', 'learning allowance' and 'below standard work'. The first was cured during the period, presumably by better production planning, and the two latter were much reduced by better operative training and supervision. Other temporary troubles were caused by 'allowances for faulty material' (13th March) and 'allowances for machine or tools' (27th February).

(iii) Performance of Indirect Workers. The Indirect Standard Minutes are estimated from a ration —80 indirect to 1,000 direct standard minutes. There has been a steady increase in the performance of these workers, though the hours worked are still above those budgeted for.

(iv) Cost. The Standard Cost is calculated from the average hourly base rate (Base Wages/Hours Attended), assuming that operatives work with no lost hours, at 80 standard minutes an hour, and earn 33% bonus. It is thus the ideal minimum cost at the existing base rates. In practice costs can never be brought as low as this, but they have in fact been reduced during the seven weeks under review, until the excess cost is down to that estimated for in the budget. The indirect cost, however, is not yet down to the budget figure.

VARIATION OF PAY AND LABOUR COST WITH OUTPUT ON VARIOUS INCENTIVE SCHEMES.

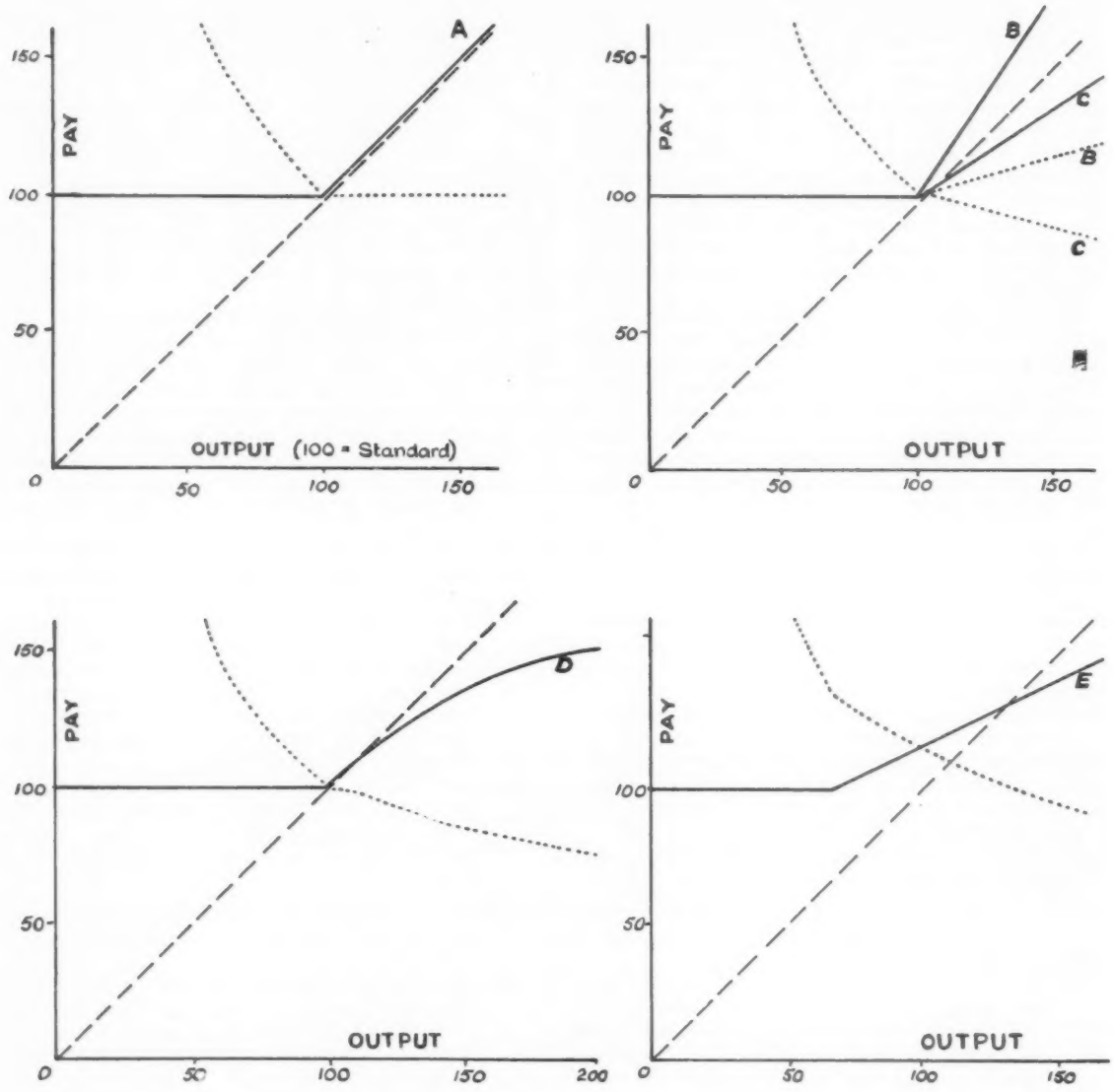

Fig. 3.

——— straight piecework without guaranteed time rate.

A straight piecework with guaranteed time rate.

B as above but with stronger incentive (1½% pay to 1% output).

C as above but with weaker incentive (1% pay to 1½% output—Halsey system).

D incentive reduced at higher output (bonus = $\frac{\text{time saved}}{\text{time allowed}}$ x time pay Rowan system).

E stabiliser to reduce fluctuations above and below incentive level ('133').

——— Pay.

..... Labour cost.

It might be thought that much clerical work would be needed to compile such detailed information. However, if there is a well-designed incentive scheme already installed in the department, the gathering of the data (which represent most of the clerical effort) is being done in any case and only a little extra computation is required to compile them in a suitable form. Furthermore, the use of the basic figures for pay calculation is an automatic guarantee that they are accurate and punctual.

Similar standards of performance can, of course, profitably be set by Management for many other fields such as material usage, overhead control and, in fact, for all the activities of the company, culminating in detailed financial budgets. For these also, control returns should be instituted to check actual performance against the standard.

Control returns do not ensure good results in themselves but only in so far as the Manager takes effective action on the information provided.

Incentive Schemes

Work study is often considered only as a foundation for an incentive scheme. This is, of course, a very important application, since any system of payment by results must be based on the best measurement of work possible. It will, however, be given less attention in this Paper since elsewhere it receives so much.

All paid labour involves a transaction, sometimes not formally recognised, between management and labour. In such simple transactions as buying sugar from a grocer, or petrol at a filling station, the importance of an accurate method of measurement is clearly recognised. In payments by results schemes, the transaction is in terms of output and must also be based on a valid, reliable method of measuring output, acceptable to each side of the transaction.

There are five points relating to the design of incentive schemes for direct workers to be noted :-

(i) A financial, payment by results incentive is only one form of incentive and, although usually the most powerful one, it may not be the only incentive towards good work or a high output that should be considered. Perhaps the most effective of all incentives is the intangible mixture of personal example, encouragement and recognition that we call leadership. Promotion, security, recognition, profit sharing and merit rating can also be made the basis of incentive schemes, though they may be incentives to staying with a firm rather than to working hard while there.

(ii) There are innumerable types of financial incentive schemes based on output. They can all, however, be summed up as different ways of drawing a line on a chart having "pay" and "output" for its axes. The chart in Figure 3 shows a few of the more common methods. By drawing the line suitably, the emphasis of the incentive can be placed on output at normal or above normal levels and various safeguards can be built into the scheme.

(iii) The incentive may be paid on an individual or a group bonus. An individual bonus is the more powerful, except where the work of operatives is mutually dependent, and co-operation must be encouraged. If groups are essential, they should be small and the members should be well matched. If possible one or two operatives who are friends should be picked as the nucleus of a group, and then allowed to select the other members so that a real team is formed from the start. It is important to consider carefully whether any particular factors in the working conditions or environment will react on the co-operation of the team.

(iv) After the incentive scheme has been designed, the basic information as to the value of the different operations performed on the work must be established by work study. This information is sometimes expressed as a single piecework price. It is better, however, that a clear distinction should be made between the time required for performing the operation (which is established by work study) and the rate at which the time is paid (established by job evaluation). The reasons for this are :-

(a) Negotiations with workers can be narrowed to the rate for the job (a proper subject for negotiation) and excluded from the measure of the amount of work in an operation (which is not a proper subject for negotiation).

(b) Changes in pay rates (occasioned by changing cost of living) should not confuse the measurement of the amount of work in the operation.

(v) Sound clerical routines should be instituted for the recording, collecting and analysis of the output from operatives, including also the duration and the reasons for any stoppages not the operative's own responsibility. Safeguards should be built into the routines to prevent abuse. It is obvious that the routines must also be prompt and accurate. If carefully designed, it is not necessary that the routines should be complicated nor expensive in clerical labour.

Control of Indirect Labour

The term "indirect labour" is a flexible one but is here taken as any departmental labour which does not directly alter the shape or condition of the product. Within an individual factory, it is necessary to specify exactly what is included in the classification to avoid confusion in costing, control returns,etc.

Many factories take great trouble over the control of direct labour, instituting work study, incentive and training schemes and control returns, but neglect

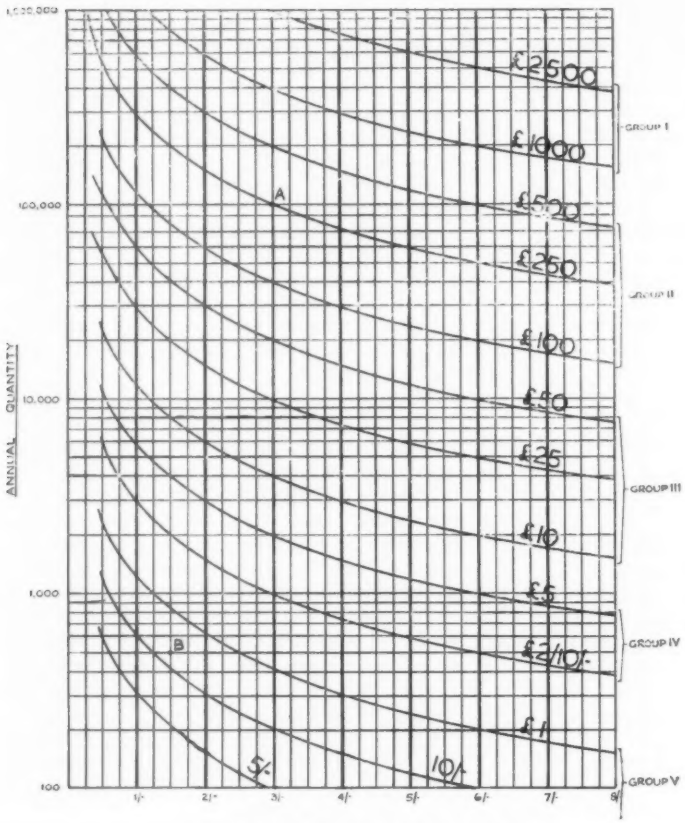

Fig. 4.

to control the indirect labour. Sometimes, however, the indirects may account for as much as 40% of the payroll and may be much in need of control.

The first essential is to set standards of performance for indirect labour and work study can be used for this also. It may not be as detailed as the study for the direct workers, but it will be as close an evaluation as is economic of the amount of work in the various duties of each indirect worker.

For Management to exercise control over indirect labour it must be informed of the amount of work performed each day or week. This report can be compiled either by actually recording the number of times a particular job is performed and multiplying by the work content of the job, or by estimating. The estimating can be done by relating the work content of the indirect operations to the work content of the direct operations performed in the department which the indirect worker serves. The relation may be expressed in the form—*X* indirect standard minutes are required for every 1,000 direct standard minutes. If the direct standard minutes of output for a department are known at the end of the week, then an estimate of the corresponding indirect work performed can be calculated from the ratio above. The labour summary shown in Fig. 2 has a section giving the estimated output of the indirect workers (ratio $X=80$) and their effective performance in standard minutes per hour.

Suitable incentive schemes for indirect labour can be based on such recording or estimating of the indirect work performed. Since the measurement and recording may not be so exact as with direct incentives, it may be advisable to use safeguards such as the payment on a group basis, the averaging of results over a week or more or the levelling out of earnings above and below the average.

Estimating and Controlling Product Costs

The allocation of overhead and labour costs to particular types of product is usually made on a basis of the time spent on a particular process, operation, machine or department, and the results of work study are therefore of direct use in estimating and recording product costs.

In jobbing work of a "one-off" character, it may not be possible to synthesise the work content of an operation in advance and the only way of deriving

costs may then be merely recording the historical cost when the operation occurs. On the other hand, whenever work study can be used to synthesise standard times, reliable estimates of the cost can be made in advance as the basis for fixing selling prices and preparing budgets of output and expenditure against a planned sales programme.

Other Uses of Work Study

The detailed analysis and evaluation made by work study of all the factors affecting the performance of an operation is valuable in many other management activities besides those already discussed. Some of these are outlined below :-

(i) improving working conditions and reducing fatigue. In work study an allowance must be made for recovery from the fatigue caused by the operation and this entails the identification of any strenuous movements and adverse working conditions, such as poor lighting, high temperatures and noise. This identification is the first and essential step in improving conditions and reducing fatigue;

(ii) plant layout and materials handling. The detailed knowledge of the operations, which is gained by the work study engineer, is a sound basis for his planning of the layout of the plant and of the handling of materials. In fact the process layout chart, which is one of the tools of method study, is essential to each of these;

(iii) planning for quality. In a negative sense, the work study engineer is, of course, deeply concerned with the maintenance of good quality since his actions in altering working methods, or encouraging operatives to increase output by incentives, may impair the standard of quality unless proper precautions are taken. It is in any case inevitable that the blame for faulty workmanship, arising from whatever cause, after he has made a reorganisation, will be laid first at his door and it is wise for him to decline this role of universal scapegoat! The necessary precautions are, first, ensuring that the inspection of the work is made a strong and independent function which can be relied on to reject faulty work so that no operative stands to gain from it and, secondly, making thorough checks of the level of quality before and after the reorganisation.

The work study engineer is well equipped to plan for quality in a more positive way, since he has intimate knowledge of the whole sequence of operations and of what actually happens at the point of contact between the material and the worker's hand, tools, or machine. Planning for quality should cover the steps as follows :-

(a) agreeing on standards of quality. This implies securing a compromise between the conflicting views of the design, production and sales sides;

(b) then putting the standard on record in a written or drawn specification. It may seem difficult in some industries to draw up such a specification, but it can almost always be done with a little clear thinking and it has great value as a permanent unambiguous record;

(c) making a check of current production in the light of the agreed standards, analysing all the faults detected, diagnosing and, so far as possible, curing their causes;

(d) planning the methods of inspection and appointing and training the necessary inspectors;

(e) checking on the quality of future production and supervising the inspectors to ensure maintaining a high standard.

(iv) production control. In many industries there are certain key departments, groups of machines or even individual machines for which production programmes must be planned in advance. The loading of work on these sections must be calculated, relating their output capacity with the volume of work ahead and ensuring that the parts and assemblies for each batch are completed in due sequence to satisfy the target dates in the programme. If the normal capacity of a section is unable to meet the loading, it may be necessary to arrange for overtime working, installing extra plant or contracting some of the work out.

The information given by work study provides a sound basis for calculating these loadings. The capacity of the sections will be expressed in standard minutes per hour or day and will be derived from the levels of performance recorded in the labour summaries; the volume of work ahead will be derived for each batch of the programme from the work study data. The latter will, of course, in the case of machines, take into account the relevant feeds, speeds and tool set-up;

(v) control of machine work and teamwork. There are many operations where idle time is caused to the operative, either because he is waiting for a machine to complete its cycle or because he is one of a team or production line which is not well enough balanced to keep every member fully and equally employed. There are several possible ways of preventing such wasted time—for instance, by giving extra machines or by reallocating work away from the more heavily loaded members of the team; a work study analysis of such an operation is valuable in detecting and evaluating the idle time and in planning to eliminate it.

In addition to the wasted time, such operations often pose a difficult problem in the payment of piecework or bonus. The work study analysis is essential to the design of an incentive scheme that will be fair to both management and operative.

(vi) job evaluation and personnel work. Job evaluation is a method of analysing and standardising job pay rates and is quite distinct from work study, which is concerned only with measuring the amount of work in an operation.

However, the information recorded during a work study investigation as to the working conditions, the skill required and the effort expended in each job is useful for compiling the job descriptions which are the basis of job evaluation. Similar job descriptions are used in selecting personnel;

(vii) an incidental service work study can perform is to provide a training ground for staff who are intended for executive positions in Production Management since it gives, in addition to a detailed knowledge of all production processes and problems, a grasp of many allied functions of management. Many modern managements therefore give their future executives training in work study.

Conclusion

In industry today, management is trying to solve a difficult equation, in which some of the variables—wages, cost of materials and overhead expenses—are rising steadily. Some firms have solved the equation for the conditions of today and, in terms of the high quality and low cost of their products, they set a standard of industrial success to the whole world.

However, these are the best results, and many firms have much to do before they can equal them. A remarkable survey recently published in this Journal showed, for instance, a ratio of 2.4 : 1 between the costs of the same product made by different sub-contractors.

Work study can be a powerful help to management in raising the standard, and it is important to realise that its use is not restricted to the large firms. It has been successfully introduced into firms with 100 employees and less; although such a firm cannot afford a full-time work study engineer, it can always release one of the staff for a period of training so that he can then apply work study principles, both through his own job and by training his fellow workers.

Appendix

GENERAL GUIDANCE FOR ASSESSING HOW MUCH WORK STUDY SHOULD BE APPLIED TO AN OPERATION

If we cannot estimate S, the expected reduction in the operation, in standard minutes, we can form some opinion as to the degree of work study which should be applied by considering the annual saving that would be gained for a reduction of only *one* standard minute per unit of product.

This will be :-

$$\frac{£Q \times (L + M)}{1.200}$$

On the assumption (which may not of course always apply) that the more intense the work study effort and the more refined the techniques that are applied, then the more standard minutes can be saved on each unit, an arbitrary set of groups of intensity of effort and technique can be set up, as a rough guide to the engineer, as shown at the top of the facing page.

The values of the annual saving per S.M. per unit that have been inserted against each group are not the result of any exhaustive costing of the various techniques but are thought to be a reasonable guide. For the higher groups, where considerable work study is indicated, they should be confirmed by a fuller savings estimate, but they serve as a preliminary guide and also give concrete illustration of how the work study should be varied to suit the economics of the operation.

Lines corresponding to various values of $\frac{£Q \times (L + M)}{1.200}$ have been drawn on the chart in Fig. 4, where appropriate groups have been indicated and which thus provides a quick answer to the question ' How much Work Study? '.

If we plot the illustration from the shirt factory quoted above, we obtain point A in the £250 line which indicates the work study techniques in Group II.

If we take another example from the shirt factory, the study engineer might find that a certain customer's order amounting to only 500 dozen shirts a year needed to be specially packed in cellophane bags; the labour rate is 1/6d.: this operation is plotted as the point B, just above the 10/- line in Group V, indicating that only a rudimentary check is required.

In contrast it may be of interest to examine an operation performed on such a vast scale that it comes far above the top of the chart, and so suggests that exceptionally valuable results might be obtained from the use of work study as well as other methods of saving work. In coal mining, 200,000,000 tons of coal are won by miners working on a base rate of about 6/- per hour. Considering the operation of digging and loading 1 ton of coal at the coal face, the annual saving for only one S.M. on each ton of coal

$$= \frac{£200,000,000 \times 6}{1.200}$$

$$= £1,000,000$$

SELECTION OF WORK STUDY TECHNIQUES

Group	Annual Saving per S.M.	Work Study Techniques to be Used
I	Above £500	Micro-film analysis of operator's movements. Design and construction of special machinery. Specific training scheme for operatives. Detailed time study and compiling of standard work data.
II	Above £50 to £500	Thorough M.T.S. analysis of operator's movements. Design of special tools, jigs and fixtures with quick handling devices, materials handling equipment, etc. Detailed time study and compiling of standard work data.
III	Above £5 to £50	Motion analysis by two handed operator chart. Simple work fixtures, arrangement of standard work bins, etc. Detailed time study of several operators for the compiling of standard work data.
IV	Above £1 to £5	Short visual examination for motion improvements and mental application of principles of motion economy. Time study values compiled from existing standard data, checked by proof study, or from special job studies.
V	Up to £1	Cursory visual examination to check whether a simple change of method can yield improvement, Time study values compiled from existing standard work data or from a job study.

The above groups are only intended as a rough guide. Apart from the wide range within each group there can also be overlapping between groups.

COURSES IN WORK STUDY

The Ministry of Education announces that in view of the increasing demand from industry for more facilities for training Work Study specialists, arrangements have been made for ten to twelve week full-time courses to be provided at the Royal Technical College, Glasgow; Loughborough College of Technology; and Leicester College of Technology and Commerce.

The courses will start in January and will be in addition to those of a similar type already running at the College of Aeronautics Work Study School at Cranfield. They will be of a type suitable for persons of 25/35 years of age holding junior or mid-executive level posts in industry, trades unions officials, education and training officers in industrial firms, and teachers in technical colleges. The tuition fee for the course will be £100, boarding costs being additional.

Further details of the courses may be obtained from the Head of the Work Study School, College of Aeronautics, Cranfield, Bletchley, Bucks.

BRITISH STANDARDS

B.S. 2051 : 1954. Steel Compression pipe fittings for engineering purposes.

Part 3 of the above British Standard has now been published and copies may be obtained on application to the British Standards Institution, 2, Park Street, London, W.1.

FILMSTRIPS ON PRODUCTION PROBLEMS

A new series of sound filmstrips, which have been designed to help solve industry's production problems, has now been issued by the Industrial Welfare Society. The series is called "People and Production" and deals specifically with the human factor in industry. Each filmstrip deals with a human relations problem, and is intended to stimulate discussion and ideas. Sample titles, which are generally self-explanatory, are: "The Executive Who Wasn't", "Papers and People", "Tool Room Trouble", and "Stick in the Mud".

Further particulars may be obtained on application to the Industrial Welfare Society, Filmstrip Section, Robert Hyde House, 48, Bryanston Square, London, W.1.

RESISTANCE WELDING IN AMERICA

by G. CUBITT-SMITH, M.Met.E., D.I.C.(Hons)., G.I.Mech.E., Grad.I.Prod.E., Grad.I.W.E.

Presented to the London Graduate Section of the Institution, 21st October, 1953.

Mr. Cubitt-Smith

Mr. Cubitt-Smith was educated at Hurstpierpoint College, Loughborough College and Rensselaer Polytechnic Institute, U.S.A. He served his apprenticeship with the English Electric Company, Limited at the Rugby and Stafford Works, and subsequently became Technical Assistant to the Welding Works Manager.

In 1949 he joined Crompton Parkinson, Limited as a Planning Engineer, and in 1950 was temporarily released from the Company to take up a Mutual Security Administration Scholarship in the United States, where he worked in a number of firms connected with the welding industry, and visited a large number of others.

In 1952 he returned to Crompton Parkinson and was subsequently appointed Production Officer for the Machine Fabrication Department.

RESISTANCE welding is, in my opinion, the most virile section of the American welding industry. In the immediate post-war period, the domestic appliance factories were eager to take advantage of the many advances made in this field during the War, creating a big demand; however, retooling programmes for military production had priority. This activity has been maintained by a large number of improvements in resistance welding processes which have opened up many new fields of application.

The expansion taking place in this industry is illustrated by the growth of the firm with which I am connected. It was founded by a small group of engineers in 1945 and in six years it had established its name and was regarded as one of the most enterprising resistance machine manufacturers in the country, employing approximately 80 men assembling resistance welders mainly from component parts manufactured outside. In this Paper I shall describe the main types of welders and endeavour to describe in more detail the recent developments.

Types of Resistance Welding Machines

Resistance welding is a group of processes employing resistance heating to promote coalescence between the two pieces of material held under pressure. A variety of special machines has been developed for specific material joining applications and for high speed production such as spot, projection, seam and butt welding; all these types are in general use in industry today. However, owing to power supply difficulties resulting from heavy intermittent demand, a number of variations has been introduced into the electrical circuit in an effort to reduce this demand and its associated difficulties, so that apart from the conventional single phase A.C. welders, there are three main groups of machines classified according to their supply characteristics :-

(a) Energy storage machines—four types :-
- (1) motor generator;
- (2) condenser discharge;
- (3) magnetic energy storage;
- (4) battery storage;

(b) Load spreading—machines designed to spread the load on more than one phase of the A.C. supply—three types :-
  (1) frequency changer machines;
  (2) D.C. dry disc rectifier machines;
  (3) multi-transformer machines coupled to one or more phases and operated in sequence;
(c) Load equalising :-
  (1) power factor correction, difficult to balance efficiently, as load changes from job to job, unless on long runs;
  (2) introduction of equivalent load to that of the welder during off time. Usually this is uneconomic unless two or more machines can be ganged together.

None of these machines, except possibly frequency changer and D.C. machines on light alloy work, possesses any particular welding advantage over the single phase A.C. machines, so that the extra initial cost can only be justified by power supply limitations or excessive tariffs, hence the selection of the electrical system for a machine becomes mainly an economic problem. The need for a thorough investigation of the power supply situation cannot be over-emphasised, both inside the works and outside with the supply authority. This should be done before installing resistance welding equipment, because in the past so many schemes have failed due to insufficient attention to this aspect incurring heavy financial losses.

My remarks will be confined, in the rest of this Paper, to the fundamentals of resistance welding, followed by a description of a fairly typical American single phase A.C. resistance welder and its associated controls, before discussing some of the latest developments (90% of all the resistance welders in service are of this type).

Principal Factors Governing Resistance Welding Process

The present-day tendency to use resistance welding in ever more critical applications demands greater consistency and more rigorous quality control. As in most other industrial processes, consistency can only be obtained by careful control of the related factors in the process. There are three primary considerations :-

(1) material
(2) welding heat
(3) welding pressure

(1) *Material*

This dictates the magnitude and limits of variance that can be tolerated without detriment. A thorough and accurate evaluation of the metallurgical characteristics of the material is an essential aid to the correct selection of equipment, material preparation processes and post welding treatment.

(2) *Welding Heat*

This is certainly the most critical factor and hardest to control. The degree of control necessary is primarily dictated by the metallurgical characteristics of the material. As a general rule, materials with a wide transformation range from the solid to liquid states can tolerate a greater heat variance, providing other factors are equal.

Heat in resistance welding is generated by the electrical resistance of the workpiece and is expressed by :-

$H = 0.24\ I^2Rt$ where H = heat
I^2 = current
R = average resistance
t = time

The welding machine controls only current and time and 'R' is a characteristic of the material. The resistance 'R' consists of two distinct factors; firstly, the specific resistance of the work material and secondly, the surface resistance which reflects the condition of the material surfaces at each interface. This second factor can vary considerably in certain materials, particularly those noted for their high resistance to corrosion. Hence to control adequately the welding process, the Process Engineer must control the surface condition; this may require the introduction of special cleaning processes, to ensure that welds of consistently good quality are obtained.

(3) *Welding Pressure*

This is required to maintain proper electrical contact throughout the welding cycle and to contain and consolidate the weld nugget by forging the plastic or molten interfaces together. Loss of pressure causes an increase in resistance resulting in overheating and burning and sometimes metal expulsion. High speed movements occur in all resistance welding processes, particularly in projection welding, so the electrode and pressure system must be capable of maintaining adequate pressure throughout the welding cycle. Fig. 1 is reproduced from a report of a study made on the electrode system at Rensselaer Polytechnic Institute (3) and shows the effect of friction and inertia on a 'weld'.

Single Phase A.C. Welders

The basic operating cycle for any resistance welding machine (Note : Flash welding machines are not included in this category as they cannot be regarded as true resistance welding machines) is shown in Fig. 2. Squeeze time is a delay normally varying from a few cycles to about one second, which allows the correct pressure to build up between the electrodes. On some machines this is controlled by a pressure switch which prevents initiation of the welding current until sufficient pressure has been developed in the system. Weld time is the time that the current flows to form the weld. There are many variations which can be introduced on certain machines to match the thermal cycle required. These will be examined in more detail later in this Paper. Hold time is introduced to prevent the electrodes opening and losing pressure before the molten metal of the weld nugget has time to solidify. Off time is the time between welds. In most machines a time delay can be switched in to make the machine repeat the welding cycle as long as the foot switch is depressed. This time may be as short as a few cycles,

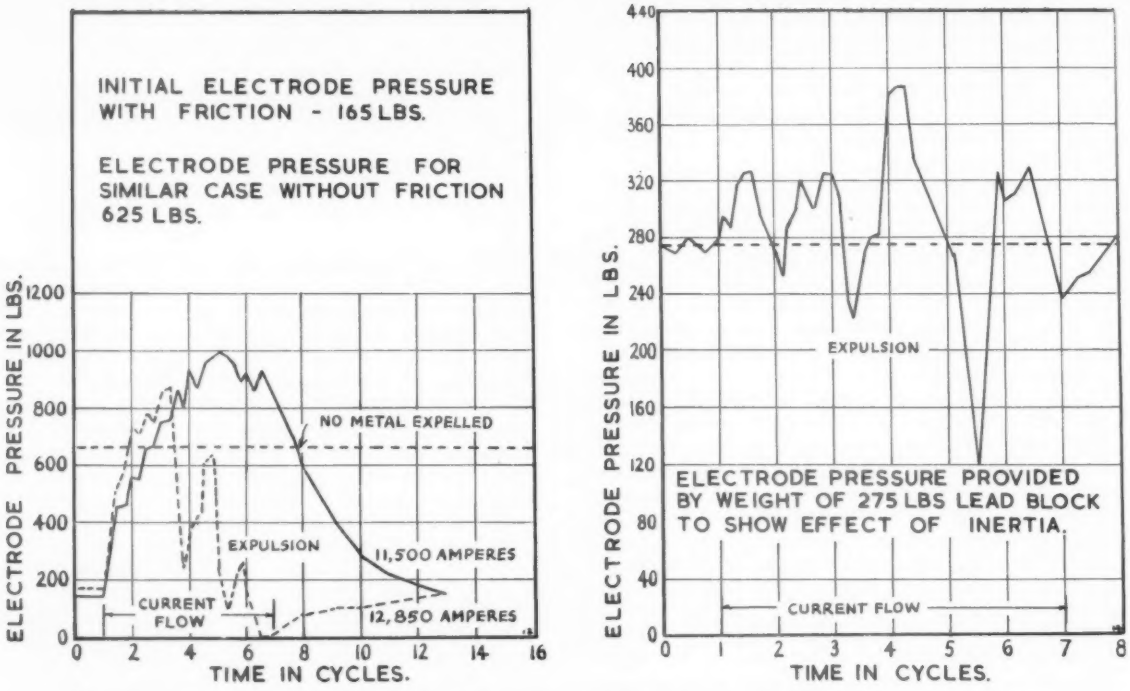
INITIAL ELECTRODE PRESSURE WITH FRICTION - 165 LBS.
ELECTRODE PRESSURE FOR SIMILAR CASE WITHOUT FRICTION 625 LBS.
ELECTRODE PRESSURE IN LBS.
TIME IN CYCLES.
NO METAL EXPELLED
EXPULSION
11,500 AMPERES
12,850 AMPERES
CURRENT FLOW
ELECTRODE PRESSURE PROVIDED BY WEIGHT OF 275 LBS LEAD BLOCK TO SHOW EFFECT OF INERTIA.
EXPULSION
CURRENT FLOW

FIGURE 1. SHOWING EFFECTS OF HIGH FRICTION AND INERTIA.

in certain mass production applications, and also the electrode travel should be as short as possible only allowing sufficient clearance for the work to be conveniently handled between the electrodes; a long stroke causes pounding and rapid deformation of the electrodes.

There are two main types of single phase A.C.

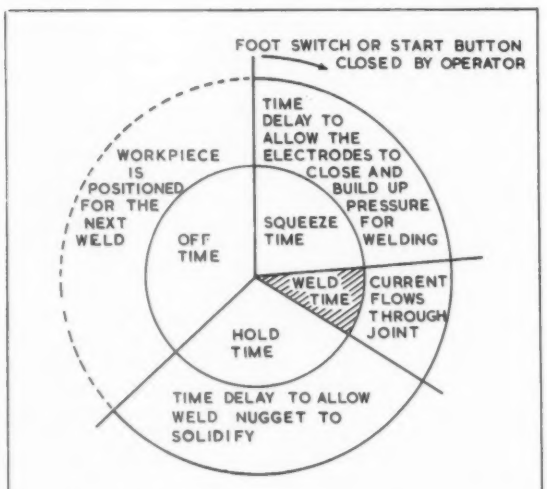
FOOT SWITCH OR START BUTTON CLOSED BY OPERATOR
TIME DELAY TO ALLOW THE ELECTRODES TO CLOSE AND BUILD UP PRESSURE FOR WELDING
SQUEEZE TIME
WELD TIME
CURRENT FLOWS THROUGH JOINT
HOLD TIME
TIME DELAY TO ALLOW WELD NUGGET TO SOLIDIFY
OFF TIME
WORKPIECE IS POSITIONED FOR THE NEXT WELD

FIGURE 2 BASIC OPERATING CYCLE.

machines in general use, synchronous and non-synchronous. The latter employ a heavy duty contactor in the primary to make and break the current; these contactors are usually magnetically operated from a timing mechanism which may be electronic, pneumatic or even manual. The latter are being replaced by the former types as the repetitive accuracy is so unreliable. Non-sychronous machines suffer from the disadvantage that heavy transient conditions can occur for the first few cycles of welding currents, if the contactor closes at the incorrect point on the voltage wave, aggravating supply problems, and may cause arcing and tip pick-up on certain critical operations. Consequently, their field of application is fairly limited.

These disadvantages are offset to some extent by the lower initial cost of the machines. Sychronous machines are controlled by electronic contactors, thyratrons for small and ignitions for larger welders. These types are the most popular today on account of their adaptability—most of the special controls that are marketed in the States as packaged units can readily be fitted and these will soon become more readily available over here. These contactors have the additional advantage of phase shift heat controls, which can be fitted to give a very fine control of the current with fewer primary taps on the welding transformer.

The principle of operation is illustrated in Fig. 3, the first part of which shows the cross-section of an ignition. There are three major components: anode,

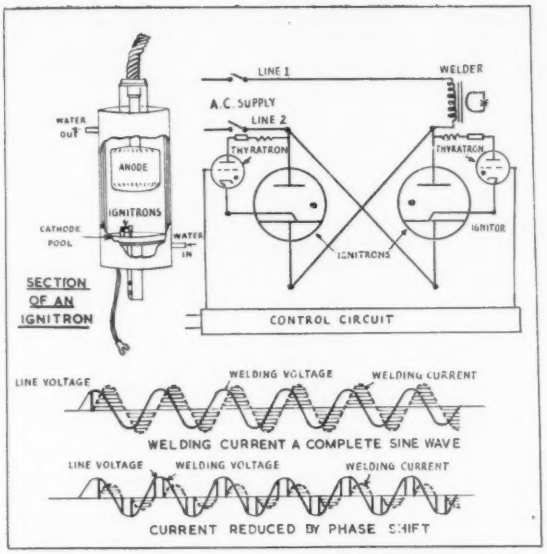

FIGURE 3 IGNITRON CONTACTOR ILLUSTRATING THE OPERATION OF PHASE SHIFT HEAT CONTROL.

cathode and igniter. The tube can conduct in one direction only, and to do so an arc must first be initiated by the igniter.

The second part of Fig. 3 shows how two ignitions are connected into a circuit to conduct an A.C. current. As the tubes require a small positive striking voltage, a small phase shift occurs. The phase shift heat control is based on delaying the ignition of the tube till later in the positive half cycle, thereby reducing the conduction time for each tube and hence less current. This is shown diagrammatically in the lower part of Fig. 2.

Three methods are used to apply the welding pressure to the electrodes. These are—mechanical, pneumatic or hydraulic. Mechanical methods are seldom used today owing to their comparatively higher cost and lower efficiency, except for manually operated machines, which are still quite popular. Pneumatic systems are by far the most popular as they are easily connected to the air lines which are available in most shops. Electrode pressures can be readily varied to suit the particular job and the control of the electrode head is fairly simple, requiring only solenoid valves. Hydraulic methods are used in hydromatic welders where it is necessary to fit a large number of electrode tips into a confined space. Most welding manufacturers have standardised on 1" or 1½" diameter cylinders for these machines. High pressure oil is obtained either from a pump or by an air pressure system. The latter method is more common because of its simplicity.

Special Features in the Design of Representative American Welder

The factors governing the design of resistance welding machines are similar whether the machine is to be used for spot, projection, butt or seam welding. The machine shown in Fig. 4 is a combination spot and projection welder set up for spot welding.

The moving head of this machine is made from a special high duty light alloy casting which is ball bearing, mounted in hardened steel ways fitted with ball retaining cages. The electrode pressure is provided by admitting compressed air into the top portion of the cylinder; the piston transmits the force through the piston rod to a knife-edge in the centre of a spring steel beam mounted in the light alloy head. This spring serves two purposes; it isolates the lower part of the head, thereby reducing the inertia so that the head is free to maintain sufficient pressure throughout the weld cycle; secondly, it closes a micro switch when sufficient electrode pressure has been developed to ensure satisfactory welding conditions. The height of the micro switch is adjusted through a head for different welding pressures.

To reduce the weight of the moving parts in this machine the upper electrode horn and platen have been cored out. The section left is just sufficient to carry the maximum electrode force and the large secondary currents. Sometimes a forging feature is required on these machines, consisting of additional electrode force applied to consolidate the weld nuggets just before the welding current is cut off. Fig. 5 is a copy of an oscillographic pattern showing the introduction of the forge during a weld. This machine does not have the forging feature fitted; however, on similar welders it is simply provided by maintaining a buckling pressure on the underside of the piston and at the required time releasing this air through a solenoid valve provided with large ports to ensure quick relief of the pressure.

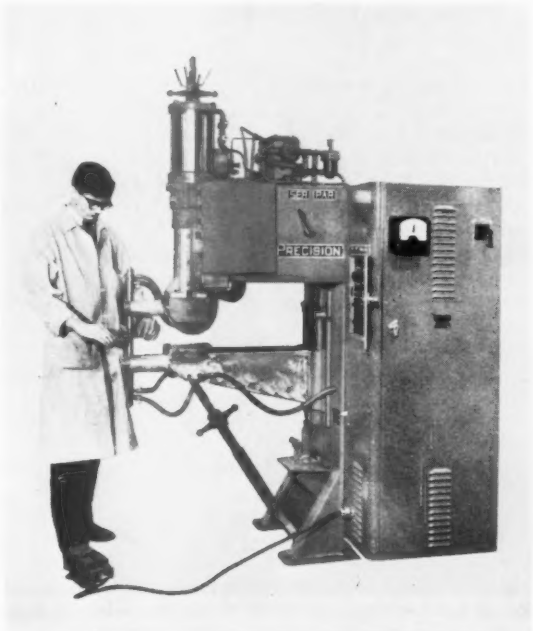

Fig. 4. 150 KvA press type spot and projection welder.

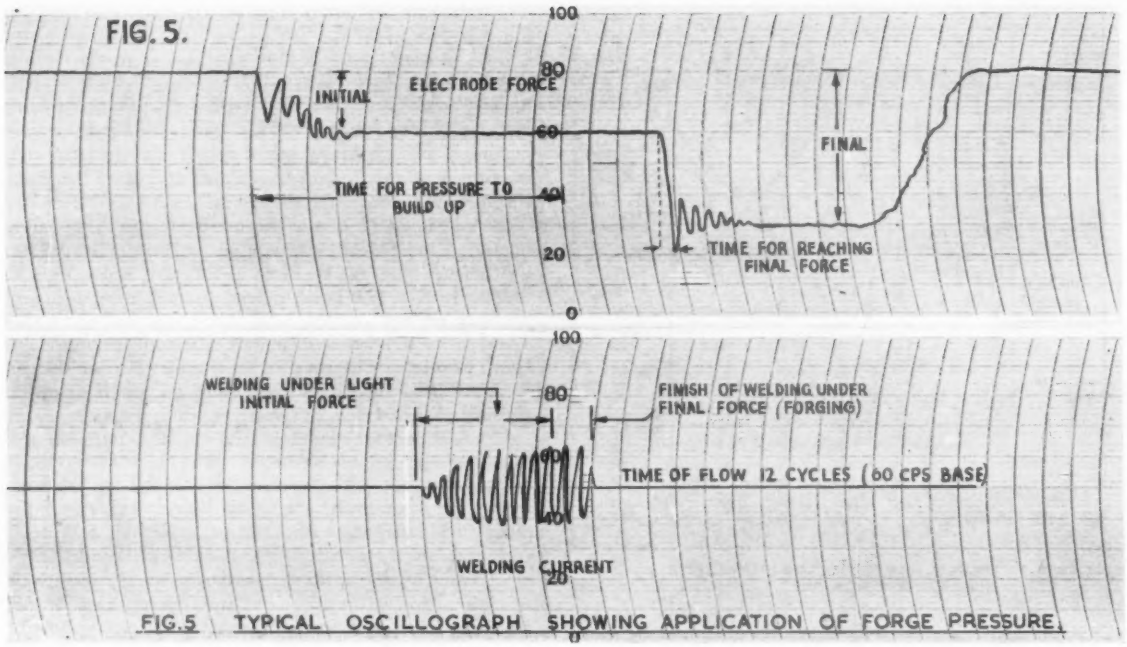

FIG.5 TYPICAL OSCILLOGRAPH SHOWING APPLICATION OF FORGE PRESSURE.

Frame rigidity is another important feature of this machine, which utilises a fabricated box type frame that is very rigid. The lower electrode is given additional support by the bar extending from the machine base. If the machine were not rigid the electrodes would skid over the workpiece as the electrode force was applied, causing rapid tip pick-up and irregularly-shaped spot welds.

The welding transformer is provided with an eight step tap switch (Fig. 4), giving wide variation of the secondary voltage in the order of 50%. The large number of steps coupled with phase shift heat control facilitates very fine control.

Most manufacturers are finding it necessary to silver plate all the secondary joints before assembly to ensure a longer trouble-free life. All the secondary members which are liable to overheat are water-cooled. This generally means the whole of the secondary circuit except the lower support and the electrode horn. Most machines provide sight gauges so that the operator can see whether water is actually flowing through the electrode holders, and on a separate circuit through the secondary of the transformer. In certain conditions thermostat valves are provided to prevent the transformer being chilled to such an extent that it sweats, which might cause an electrical breakdown. Recently attention has been focused on the resistance of the secondary circuit; in service the resistance gradually builds up, resulting in loss of welding heat which eventually causes a serious loss of weld strength, with the result that when sample testing is carried out at regular intervals a large number of components could pass through the machine before the trouble is discovered. One company engaged in the manufacture of aircraft components finds it necessary to strip the secondary circuit completely and remake all joints at intervals of three to four weeks to prevent troubles of this kind. All the secondary joints in the machine shown in Fig. 4 were silver plates.

Often insufficient attention is paid to water cooling and tip dressing of electrodes in production. An adjustable quill provided in the electrode holder should always be set so that it extends to the end of the elecrode right under the welding tip. Maximum electrode life will then be obtained and the frequency of dressing reduced. There are a number of devices available to assist in dressing operations and most machines are fitted with a switch which allows the head to be brought down to the lower electrode by its own weight, so that a fairly satisfactory pressure is obtained for this operation.

The electronic controller for the welder shown in Fig. 4 is a leading manufacturer's standard synchronous spot and projection welding control. This unit can be fitted with a variety of sequence timers and controls, so that it is possible to simulate the most satisfactory thermal cycle required from a metallurgical standpoint. In addition to the basic frequency timer, this controller can be fitted with :-

(1) ***Weld sequence timer.*** This control has individual heat and cool timers for pulsation welding.

Fig. 6 shows the use of this unit diagrammatically.

(2) ***Forge delay timer,*** used to control the solenoid valve which dumps the buckling air pressure mentioned earlier.

(3) ***Quench and Tempering Control.*** This is used in conjunction with a second phase shift heat control so that the correct degree of reheating can be obtained for past heat treatment of the weld. For research a programme controller incorporating a large number of these cool and reheat cycles is used. Fig. 7 shows one of these with 10 stages allowing thermal treatments of the workpiece lasting up to about 5 minutes.

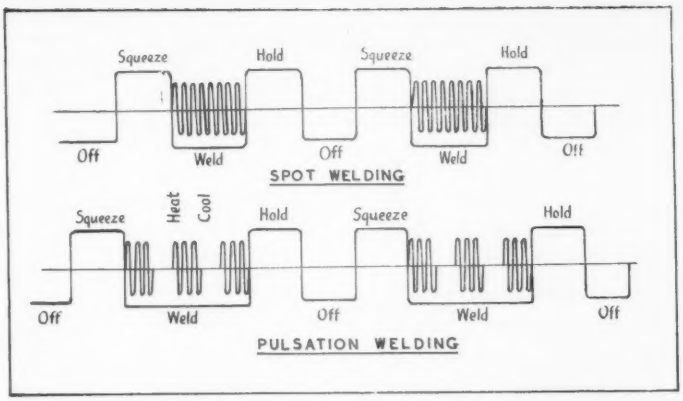

FIGURE 6 TYPICAL OSCILLOGRAPH PATTERNS OBTAINABLE FROM THE SAME MACHINE USING A SEQUENCE CONTROL

(4) ***Current Regulators.*** Two types are available to maintain the welding current constant by compensating for external variation. One is designed to compensate for line voltage variations, the other for differences in the secondary inductance caused by the introduction of magnetic materials into the thread of the welder.

(5) ***Slope Control.*** This is the latest device added to the standard controller (5). Fig. 8 is a copy of an oscillographic recording of the secondary voltage when one of these controls has been added. By electronically changing the ignition point of the ignitions, a positive or negative slope control can be obtained. Positive slope control has been found to be most beneficial in reducing tip pick-up on material with a poor surface condition and coated materials, as the low initial current allows the tips to bed down on to the work before the full welding heat is applied. Negative slope control prevents rapid quenching and sometimes removes the necessity for post-heat-treatment; it is also beneficial in preventing shrinkage cracks.

All these variations in the basic sequence of the mechanical and thermal forces acting on the workpiece enables the production or welding engineers to select the most suitable sequence for their particular material, irrespective of the type of welding process being used.

The introduction of electronic controls has greatly increased the versatility of resistance welding machines, so that today they provide one of the most economic and convenient methods of heat treating small components to complicated thermal cycles. Furthermore, these machines are also being used for a variety of other metal joining processes such as soldering and brazing, and for heat riveting and setting, although it is not always necessary to use electronic controls for these applications.

Special Developments

Research is being directed towards the simplification of resistance welding equipment and methods available for measuring the dynamic electrical and mechanical quantities, so that greater control can be exercised over the day to day working of machines.

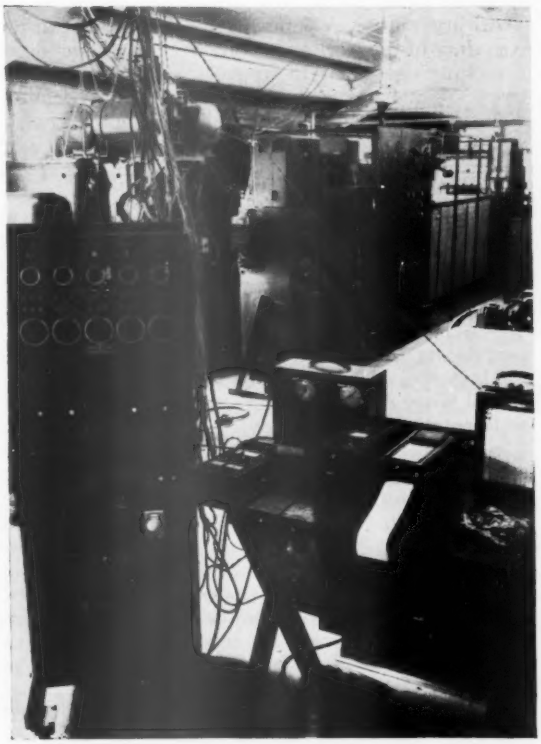

Fig. 7. F 170 programme controller and brush direct inking magnetic oscillograph.

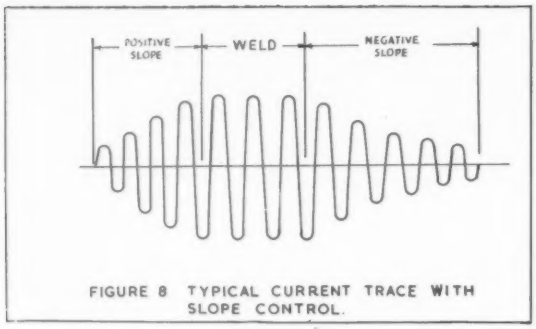

FIGURE 8 TYPICAL CURRENT TRACE WITH SLOPE CONTROL.

The importance of repetitive accuracy is well appreciated, in conjunction with the necessity of maintaining clean working conditions and the correct preparation of the workpieces.

A number of firms is marketing robust oscilloscopes for use by production and welding engineers, but these instruments tend to be expensive and are by no means foolproof, so that considerable experience is required in handling the equipment and interpreting the results. However, better progress has been made in checking the material preparation and instruments for measuring surface resistance are available. These have been designed for use on the shop floors so that once surface resistance limits have been set, rigid spot checks can be made.

An interesting development in connection with the resistance of the workpiece is the recent production of a monitoring circuit to control a resistance welder, based on the change in resistance during welding. The problems involved in developing such a control will be appreciated. If it proves successful it will have great implications. At present it is being tested under production conditions.

One firm is engaged in developing a method of testing the resistance of the secondary circuit on the principle of a cable tester, but the large cross-sectional areas of the conductors present special problems.

One method of overcoming production hold-ups, used by at least one firm with extensive resistance welding operations in the States, is to maintain a special panel fitted with every type of sequence timer and control likely to be needed in the works. When a controller becomes erratic or breaks down, the spare is plugged in to keep the production line flowing while the controller is repaired.

Finally, an interesting development showing promise in the field of machine design is a welder utilising an electromagnet to apply the welding pressure. A number of machines has been produced based on this principle. They are particularly useful in welding materials such as copper and silver which are difficult to weld on conventional machines, due to their high electrical conductivity. An investigation of the characteristics of these machines (8) showed that the weld was produced on a rising electrode force curve whose shape and delay time could be varied without resorting to electronic controls, so that the repetitive accuracy in relation to the welding current was practically perfect. Further investigation showed that the machine tended to be self compensating. For instance, a reduction in the welding current which would normally reduce the weld heat was compensated to a large degree by reduced welding pressure exerted by the electromagnet, thereby increasing the resistance and hence heat. With a soft iron core full electrode force was developed by the electromagnet almost instantaneously, so that it was possible to maintain sufficient pressure to make projection type welds in aluminium alloys.

Conclusions

The application of resistance welding requires efficient production planning, particularly in respect of machine design, material preparation and handling methods.

The special characteristics of these machines necessitate co-operation between the electric supply authorities, machine manufacturers and industrial users.

Some of the American developments described should be fully investigated with regard to their possible use and further development in this country.

English manufacturers should undertake more ambitious development work on their own account and manufacture more of the special machines available in the States.

Acknowledgments

I am indebted to Rensselaer Polytechnic Institute and to Precision Welder and Machine Corporation for their hospitality and assistance; also to the British and American Governments who organised and operated the Mutual Security Aid programme, under whose auspices my visit to the United States was made, and, finally, to Crompton Parkinson Ltd. for help in preparing this Paper.

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(4) F. H. Mathews; 'Elements of Quality Control in Spot Welding Aluminium for Aircraft.' *Electric Arc and Resistance Welding III Papers presented at the 3rd Electric Welding Conference, October,* 1952.

(5) I. W. Johnson; 'Slope and Taper Control in Spot Welding 24 st. Aluminium.' *Electric Arc and Resistance Welding III* (*see* 4) *pp.* 145.

(6) H. D. Van Scriver; 'Spot-Weld Monitoring by Resistance Change.' *Electric Arc and Resistance Welding III* (*see* 4) *pp.* 101.

(7) H. F. Storm; W. B. Hills; S. S. Barnhart; 'Electric Control for Monitoring Resistance Change during Spot Welding.' *Electric Arc and Resistance Welding III* (*see* 4) *pp.* 114.

(8) M. Zucker; G. Cubitt Smith; 'Magnetic Force Welding.' *Welding Journal, December,* 1952.

REPORT OF THE MEETING OF COUNCIL

Thursday, 28th October, 1954.

THE second Council Meeting of the 1954/55 Session was held at 10 Chesterfield Street, London, W.1., on 28th October, 1954. The Meeting was presided over by Mr. H. Burke, Immediate Past Chairman of Council, in the unavoidable absence of the Chairman and Vice-Chairman. The Meeting was attended by 28 members, and the following were present by invitation :-

Mr. L. A. Childs, Hon. Secretary, Eastern Region; Mr. R. Hutcheson, Hon. Secretary, S. Eastern Region; Mr. H. M. Sawyer, Chairman, Cornwall Section; and Mr. C. H. Spearing, Chairman, Western Graduate Section.

Finance

The Income and Expenditure Account as at 30th September showed a healthy financial position, the trend of expenditure being marginally under budget, while the trend of income was marginally over budget.

National Conference, 1955

It was reported that the Institution would hold a National Conference at Margate on 16/19th June, 1955, to consider the implications of the advent of the automatic factory. A Conference Organising Committee had been set up under the chairmanship of Major-General K. C. Appleyard, C.B.E., and a Programme Sub-Committee under the chairmanship of Mr. A. F. Kelley.

Summer School, 1954

The Secretary reported that a successful Summer School had again been held at Ashorne Hill. Although the numbers attending were lower than usual, the quality of the School had been very high.

Education for Production in Canada

The Secretary informed Council that the Ryerson Technical Institute in Toronto had now offered to provide tuition for the Institution's examination, and this removed a major obstacle in the recruitment of young members in Canada. If employers in Toronto supported the College by encouraging their apprentices and junior engineers to take advantage of the facilities now available, a significant development of the Institution in Canada might well result.

Hazleton Memorial Library

It was reported that the Library Committee were well satisfied with the new facilities and equipment, and felt that the Institution now had a Library of which it could be justly proud. The forthcoming publication of the catalogue would indicate to members the extent of the material available to them. It is believed that the catalogue will be the first comprehensive bibliography of literature in the production engineering field.

Council were very sorry to learn that the Institution would shortly be losing the services of the Librarian, Mrs. P. L. Steane, who was leaving to devote the whole of her time to her domestic life. Her work in creating a completely new library from practically nothing had been of inestimable value to the Institution.

Lord Austin Prize, 1953

It was reported by the Education Committee that the 1953 Lord Austin Prize for the best essay by a Graduate had been awarded to Mr. D. Whitehead, of Liverpool, for his essay on " Incentive Systems ".

Institution Papers

The attention of Council was drawn to the fact that the 1954 Viscount Nuffield Paper would be presented at the Royal Institution, London, on 9th December, 1954, by Major-General W. A. Lord, C.B., C.B.E., Director of Mechanical Engineering at the War Office. General Lord would speak on the vital importance of the application of modern production technology and management to the work of the Corps of Royal Electrical and Mechanical Engineers.

Arrangements for the 1954 George Bray Memorial Lecture were almost completed and an announcement would be made at the next Council Meeting.

The Papers Committee expressed gratitude to those Sections and individual members who had forwarded suggestions for Institution Papers.

The Journal

A new series of leading articles had been introduced in the October issue of the Journal, under the general heading of " Education and Research for Production ".

Advertisers continued to support the Journal and the forward position in this respect appeared to be satisfactory.

Standards

The Standards Committee continued its work of commenting on draft British Standard Specifications, and maintaining a close liaison with the British Standards Institution.

The suggestion that meetings of Standards Engineers should be organised by the Institution had been further considered, and it had been agreed that such meetings should take the form of annual conferences. It was hoped that detailed recommendations could be made at a later meeting.

Research

The following reports were made on behalf of the Sub-Committees of the Research Committee :-

Materials Handling

The one-day Conference on Materials Handling, held in Birmingham on 23rd October, had been most successful, and was attended by over 200 members and friends. (A report appears on page 714 of this Journal.)

Some Case Studies had been received from Sections, in response to the notice in the June issue of the Journal, but it was hoped that more would be forthcoming.

Production Control

Work on the Draft Joint Report on Production Control and Works Statistics, in collaboration with the I.C.W.A., had been virtually completed, and it was hoped the draft would shortly be available for consideration by the Research Committee.

Materials Utilisation Sub-Committee

Preliminary work had commenced on selection and grouping of the Case Studies received.

Sources of Information

Decision had been reached on the form the proposed directory should take, and lists of suitable institutions, and so on, for inclusion, were now being compiled.

The Chairman of the Research Committee, Mr. B. H. Dyson, referring to the sterling work of the Materials Handling Sub-Committee for the past four years, said that the F. & G. P. Committee had agreed to the setting up of a small Committee to investigate the possibility of setting up a number of specialist divisions to deal with specified branches of production engineering. There were many difficulties to contend with, but as the Institution extended its activities, such difficulties would have to be faced. It was not, however, anticipated that any recommendation would be made in the immediate future.

Joint Meeting with Operational Research Society

It was reported by the Finance and General Purposes Committee that the Institution would hold a Joint Meeting with the Operational Research Society on 20th December, 1954, in the Main Hall of the Royal Society, London, at 2.30 p.m., when Professor T. U. Matthew, of Birmingham University, and Mr. Winston Rodgers, of D.S.I.R., would discuss "The Accuracy and Function of Time Study".

Membership

Council adopted the recommendation by the Finance and General Purposes Committee that where the Section Committee and the Membership Committee recommendations to Council concerning an application for membership agreed, the applicant should be informed in advance of the Council meeting that this recommendation was to be made.

President-Elect

Council unanimously adopted the Finance and General Purposes Committee's recommendation that Sir Leonard Lord, K.B.E., Chairman of The British Motor Corporation, Ltd., be elected Vice-President of the Institution, and President-Elect.

It was a great honour for the Institution, said the President, Sir Walter Puckey, that such a distinguished production engineer—indeed, a distinguished man in every sense of the word— had accepted the Institution's invitation to become its next President. He felt sure that Sir Leonard would be an aggressive leader, and that the Council would greatly enjoy working with him.

Life Subscriptions

A recommendation by the Finance and General Purposes Committee that monies received in respect of life subscriptions should be invested, and that a life subscription fund should be created, was adopted.

Corresponding Member in B.W.A.

Council were pleased to accept a recommendation that Mr. H. F. Halfter, Associate Member, should become the Institution's corresponding member for British West Africa.

Local Section Reports

Council received a number of reports from Local Sections, extracts from which appears on pages 708 to 712 of this Journal.

Elections and Transfers

Council approved a number of transfers and elections to membership, details of which appear on pages 707 and 708 of this Journal.

Institution Blazer Badges

Council considered a suggestion that the Institution should make blazer badges available to members, and examined sample badges. It was decided not to proceed further with the idea.

Obituary

Council recorded with regret the deaths of the following members :-

J. T. Burford, M.I.Prod.E.
R. Cassels, A.I.Prod.E.
J. Cullimore, M.I.Prod.E.

Captain F. W. Spencer, M.I.Prod.E.
J. Stanners, A.M.I.Prod.E.
E. A. Young, A.M.I.Prod.E.

Report on Industrial Engineering

A full and detailed discussion took place on the recently-published British Productivity Council Report on "Industrial Engineering". Opening the discussion, the Chairman cordially welcomed Mr. W. F. Garnham, leader of the team which had visited the United States, and two other members, Mr. H. Rothwell and Mr. A. Hayek, who were all members of the Institution, who made valuable contributions to the discussion, from which much useful information resulted.

Date and Place of Next Meeting

Thursday, 27th January, 1955, at 10 Chesterfield Street, London, W.1., at 11.00 a.m.

ELECTION OF MEMBERS

28th October, 1954.

The following were elected to membership by Council:

ADELAIDE SECTION

TRANSFERS
FROM ASSOCIATE MEMBER TO MEMBER
F. R. W. Charlton, W. L. Hemer.

BIRMINGHAM SECTION

AS ASSOCIATE MEMBERS
J. Jenkins, D. J. Woods.
AS GRADUATES
A. Collett, D. N. Everton, G. H. Gummery, F. J. Haddock, G. I. Teeling.
AS STUDENTS
J. M. Hartshorne ,H. T. Hayward.
TRANSFERS
FROM GRADUATES TO ASSOCIATE MEMBERS
R. J. Harris, A. Lawlor, H. W. Lawton, E. T. Rudge, R. P. Sampson, K. A. Smart, D. H. W. Thomas, C. Withington.

BOMBAY SECTION

AS STUDENTS
S. Acharya, A. K. Basistha, S. P. Chopra, A. K. Das, B. Datta, D. S. Iyer.

CALCUTTA SECTION

AS ASSOCIATE
A. Das Gupta.
TRANSFERS
FROM ASSOCIATE MEMBER TO MEMBER
P. Bhattacharji.
FROM GRADUATE TO ASSOCIATE MEMBER
E. W. H. Scaife.

CANADA SECTION

TRANSFER
FROM GRADUATE TO ASSOCIATE MEMBER
R. E. Garner.

COVENTRY SECTION

AS GRADUATES
M. Deakin, D. A. Reynolds.
AS STUDENTS
L. A. Hoefkens, G. Viner.
TRANSFER FROM
GRADUATES TO ASSOCIATE MEMBERS
R. F. C. Acford, F. A. Mee.
STUDENT TO GRADUATE
C. Bell.

DERBY SECTION

AS ASSOCIATE MEMBERS
V. C. Harrison, W. Tanner, F. K. Webster, N. A. Whitaker.
AS GRADUATES
A. W. Loten, K. V. Stanley
TRANSFERS
FROM GRADUATES TO ASSOCIATE MEMBERS
W. I. Roberts, P. Warburton.
FROM STUDENTS TO GRADUATES
R. Holyoake, A. Whittaker.

DONCASTER SECTION

AS MEMBER
C. F. Rose.

DUNDEE SECTION

AS ASSOCIATE MEMBER
B. E. Price.
AS GRADUATE
G. G. Stewart.
AS STUDENT
D. C. Paterson.

EASTERN COUNTIES SECTION

AS MEMBER
W. H. Shilling.
AS ASSOCIATE MEMBERS
T. A. Jinks, B. E. Peart, Lt.-Col. A. Miskin.
TRANSFERS
FROM GRADUATES TO ASSOCIATE MEMBERS
H. L. Robinson, F. Veevers.

EDINBURGH SECTION

AS MEMBER
E. Hebblethwaite.

GLASGOW SECTION

AS MEMBER
J. W. Atwell.
AS ASSOCIATE MEMBER
T. Hunter.
AS GRADUATES
A. B. Raha, A. B. Reid, W. Thomson.
AS STUDENTS
G. H. Barclay.
TRANSFERS
FROM GRADUATES TO ASSOCIATE MEMBERS
J. Barr, W. Simpson, C. R. Webster.

GLOUCESTER SECTION

AS GRADUATE
A. Arkell.
TRANSFER
FROM ASSOCIATE MEMBER TO MEMBER
M. C. Garrington

HALIFAX SECTION

AS ASSOCIATE MEMBER
A. J. Jemmison.
AS STUDENT
B. C. Giebultowicz.
TRANSFERS
FROM ASSOCIATE MEMBERS TO MEMBERS
R. W. Asquith, W. A. Hannaby, G. W. Nicholls.
FROM GRADUATES TO ASSOCIATE MEMBERS
J. Hepper, F. R. Mottershead.

LEICESTER SECTION

AS ASSOC ATE MEMBER
R. B. Dann.
AS GRADUATES
G. Barnett, N. A. Beesley, J. R. Ellis, H. Rashid.
AS STUDENTS
H. C. Clews, L. Salinas-Estenssoro, J. Lovell, J. M. Smith, R. Lonsdale-Vasquez, M. P. Yates.

LINCOLN SECTION

AS ASSOCIATE MEMBER
N. Palmer
AS GRADUATE
J. K. Willcock
TRANSFER
FROM ASSOCIATE MEMBER TO MEMBER
R. Preston.

LIVERPOOL SECTION

AS STUDENT
J. D. Franklin

LONDON SECTION

AS ASSOCIATE MEMBERS
A. F. Bowman, C. E. Child, F. J. Dean, J. T. Galvin, R. W. Hillyer, F. Kramer, J. H. Pearson, G. S. Richards, K. F. Sneesby, J. L. Sutherland, W. A. Whitlock.
AS ASSOCIATES
D. Houston, W. B. Trenholme.
AS GRADUATES
J. G. Brooks, G. J. Bullock, J. P. Devall, P. J. Dewsnap, R. S. Eames, D. S. Flood, E. F. Free, J. V. Harding, A. J. King, W. M. Lassally, I. E. Scarlett, R. H. Seally.
AS STUDENTS
R. P. Brackenbury, I. Butcher, J. D. Coleman, S. Haines, J. W. A. Hodge, B. C. Jessop, J. T. Russell, H. F. Warren, D. A. Wilson.
TRANSFERS
FROM ASSOCIATE MEMBERS TO MEMBERS
E. Alexander, W. H. Kimpton, E. W. C. Wilder.
FROM GRADUATES TO ASSOCIATE MEMBERS
W. H. Bosher, J. C. Clarke, P. A. Coker, N. Herbert, F. C. Munns, H. V. S. Smith, J. F. Tennant.
FROM STUDENTS TO GRADUATES
D. T. J. Ford, F. Haslam, B. H. Noyes, P. G. L. Scott, K. R. Snowden, G. M. Vine.

LUTON SECTION

AS ASSOCIATE MEMBERS
D. French, A. Smith
AS GRADUATE
D. R. Stevens.
AS STUDENT
D. Wright.
TRANSFERS
FROM GRADUATES TO ASSOCIATE MEMBERS
A. F. Abrahams, C. R. Shotbolt.

MANCHESTER SECTION

AS ASSOCIATE MEMBERS
F. Danson, W. J. Donovan, P. R. Lofthouse.
AS GRADUATES
G. M. Astles, J. Hartley.

MELBOURNE SECTION

AS GRADUATE
D. S. Worthington
TRANSFER
FROM ASSOCIATE MEMBER TO MEMBER
J. M. Steer.
FROM STUDENT TO GRADUATE
D. C. Marley.

NEW AFFILIATED FIRMS:	NEW AFFILIATED REPRESENTATIVES:
William Adams & Co. Ltd. ...	A. H. Uhl. G. Adams.
Die Casters Ltd....	J. B. Wallace. E. A. Vary.
Ferrocast Pty. Ltd.	P. C. Tiech. W. P. Bannister.
John McIlwraith Industries Ltd.	C. H. Benjamin. I. Fullerton.
McPhersons Ltd.	J. S. Addison. G. Montgomery.
Ramset Fasteners (Aust.) Pty. Ltd.	R. Speirs. B. Elliott.
Repco Ltd.	D. E. Callinan. L. Stern.

NORTH EASTERN SECTION

AS STUDENTS
A. Etchells, M. Rumney.
TRANSFERS
FROM GRADUATES TO ASSOCIATE MEMBERS
A. Gilmore, G. P. Tomlinson.

NORTHERN IRELAND SECTION

AS MEMBER
H. E. Collins.
AS ASSOCIATE MEMBER
C. J. Dennis.

NOTTINGHAM SECTION

AS MEMBER
H. L. Palmer
AS GRADUATES
G. Brown, C. Varley.
AS STUDENT
E. Reynolds.
TRANSFER
FROM ASSOCIATE MEMBER TO MEMBER
L. Shenton.

OXFORD SECTION

AS GRADUATE
P. R. Moon.
AS STUDENTS
R. H. Clarke, J. G. Holland.
TRANSFER
FROM STUDENT TO GRADUATE
B. H. Roberts.

PRESTON SECTION

AS ASSOCIATE MEMBERS
S. Atherton, J. Sedgwick.
AS GRADUATES
M. A. Goody, A. J. Hutton, J. W. Ramsden.
AS STUDENTS
F. S. Haydock, G. Wright.
TRANSFERS
FROM ASSOCIATE MEMBER TO MEMBER
N. B. Hope
FROM GRADUATE TO ASSOCIATE MEMBER
W. E. Gregory.

NEW AFFILIATED FIRM:	NEW AFFILIATED REPRESENTATIVES:
Gearaide Limited	D. E. Fitton. R. A. Fitton.

READING SECTION

AS GRADUATE
W. P. Winterton.
TRANSFERS
FROM GRADUATE TO ASSOCIATE MEMBER
A. L. Willett.
FROM STUDENT TO GRADUATE
M. J. Inston.

NEW AFFILIATED FIRM:	NEW AFFILIATED REPRESENTATIVES:
Radio Heaters Limited	S. R. Hawkins. B. Kellett.

ROCHESTER SECTION

AS MEMBER
R. S. Chambers.
AS GRADUATES
H. N. Newman, E. E. Rees.
AS STUDENTS
D. E. Allen, F. Packham.
TRANSFER
FROM GRADUATE TO ASSOCIATE MEMBER
M. R. Mansell.

SHEFFIELD SECTION

AS ASSOCIATE MEMBERS
E. J. Jones, J. W. Martin.
AS GRADUATES
S. Pardy, L. Walker.

SHREWSBURY SECTION

AS ASSOCIATE MEMBERS
A. E. Donnelly, W. T. Thompson.

SOUTH AFRICA SECTION

AS ASSOCIATE MEMBER
A. Chalmers.
AS GRADUATE
T. R. Ockerse.

SOUTH ESSEX SECTION

AS STUDENT
D. Cowper.
TRANSFERS
FROM ASSOCIATE MEMBER TO MEMBER
H. C. Perry.
FROM GRADUATES TO ASSOCIATE MEMBERS
R. C. Farr, E. N. White.

SOUTH WALES SECTION

AS STUDENT
J. C. Challenger.
TRANSFER
FROM ASSOCIATE MEMBER TO MEMBER
J. C. Sanders

SOUTHERN SECTION

AS ASSOCIATE MEMBER
H. J. Weeks.
AS GRADUATES
G. A. E. Fielder, R. E. Peckham, I. P. Tylor.
AS STUDENTS
J. R. D. DeUphaugh, G. S. Knight.
TRANSFERS
FROM ASSOCIATE MEMBER TO MEMBER
F. A. E. Pritchard.
FROM GRADUATE TO ASSOCIATE MEMBER
C. W. Whitehead.

STOKE-ON-TRENT SECTION

AS MEMBER
R. J. Silver.
AS ASSOCIATE MEMBER
F. Carr.
TRANSFERS
FROM GRADUATES TO ASSOCIATE MEMBERS
S. Friesner, D. Hassall.

SYDNEY SECTION

TRANSFER
FROM STUDENT TO GRADUATE
R. H. Green

WEST WALES SECTION

AS MEMBER
G. E. Halter
AS ASSOCIATE MEMBER
J. Winstone.
AS GRADUATE
J. Morris.
TRANSFER
FROM GRADUATE TO ASSOCIATE MEMBER
F. W. Bevis.
FROM STUDENT TO GRADUATE
T. M. James.

WESTERN SECTION

AS ASSOCIATE MEMBERS
C. P. Adams, N. H. Bird, S. E. C. Ogden
AS GRADUATE
D. B. Moir.
AS STUDENT
K. D. Marwaha.
TRANSFER
FROM ASSOCIATE MEMBER TO MEMBER
C. C. Cornford.

WOLVERHAMPTON SECTION

AS GRADUATES
M. D. Chattaway, R. J. Sury.
AS STUDENTS
W. Hammond, W. Perry.
TRANSFERS
FROM GRADUATE TO ASSOCIATE MEMBER
E. R. Walker.
FROM STUDENTS TO GRADUATES
J. S. Fereday, E. H. Mountford, R. G. Wilbrey.

WORCESTER SECTION

AS GRADUATE
P. L. Coad.
TRANSFER
FROM GRADUATE TO ASSOCIATE MEMBER
E. R. Nicholls.

YORKSHIRE SECTION

AS ASSOCIATE MEMBER
W. Pickles.
TRANSFER
FROM GRADUATE TO ASSOCIATE MEMBER
S. M. Maude.

NO SECTION

AS ASSOCIATE MEMBER
R. A. Gill.
TRANSFER
FROM ASSOCIATE MEMBER TO MEMBER
L. C. Seager.
FROM GRADUATE TO ASSOCIATE MEMBER
S. Li.

EXTRACTS FROM LOCAL SECTION REPORTS

Presented to the Council, 28th October, 1954.

EAST AND WEST RIDINGS REGION

Doncaster

Since the last report, the new Chairman, Mr. Whitehead, has taken office. There has been a steady flow of membership applications, giving about a 50% increase in membership since the commencement of the Doncaster Section.

A full programme of lectures has been arranged for the coming Session, the first being a lecture by one of the Committee members, Mr. T. B. Maddison, on "Production Methods in Railway Workshops." Local members were circularised with regard to the Regional meeting at Huddersfield in October.

Halifax

The Section Hon. Secretary, Miss N. E. Bottom, was unable to submit a Report owing to indisposition.

Sheffield

The Sheffield Section Committee were very concerned with the response to the appeal for the Headquarters Building Fund, and launched a campaign throughout the Section. A circular letter was sent out to all members from the Chairman, and Committee members made personal contacts with friends and acquaintances. As a result of this drive the total has reached two-thirds of the target figure, and there are reasonable hopes that the full figure will be reached shortly.

The final details of the Graduate Prize Scheme have been completed, and explanatory letters and conditions sent out to all Graduates.

Sheffield Graduate

The most popular attraction has been the evening works visits. The theme for the current session is planned to cover "Material Handling" and it is hoped to visit a coal mine, a bakery, and a canning factory to study this subject.

One semi-social event was arranged in the form of a full day visit to Speke Airport, Liverpool, through the Mersey

Tunnel and ending in a tour of an ocean-going liner in Liverpool Dock.

In September, the Section in conjunction with the Halifax and Yorkshire Graduate Sections held a Regional week-end School at Ilkley. The theme was "Cheaper Production". This event was highly successful, due in no small way to the excellent speakers, and the presence of the guests, Mr. G. R. Pryor, Mr. F. J. Everest, and Mr. H. Wyndham Badger, the Institution's Education Officer. This was the first event of its kind under the new regional organisation.

After a suggestion by the Committee, a Graduate Award Scheme has been devised and introduced by the Senior Committee for a prize to be awarded for the best paper by a Graduate or Student. Details have been circulated.

Yorkshire

The syllabus for the 1954/55 Session has been completed, and it is hoped that the subjects catered for will interest every member of the Section.

During the period covered by this report no meetings have been held; golf has been the main interest of some of the members. The annual competition for T'owd Tin Pot was played on Alwoodley Golf Course and the winner was Mr. J. L. Townend, Secretary of the Section. The annual match was played against the Leeds Association of Engineers, and this year the Section were unfortunate in losing by three matches to two, but both events were very much enjoyed by the members who took part.

EASTERN REGION

Eastern Counties

The only activity of the Section this Quarter, apart from Committee meetings, has been the Annual Works Summer Visit. This year, members of the Section were pleased to accept an invitation from Messrs. Lake & Elliott Ltd., and an enjoyable and interesting visit was made to their works at Braintree.

An interesting programme has been arranged by the Section Committee for the coming winter, including a lecture by Sir Walter Puckey in January.

MIDLAND REGION

Birmingham

In June the summer outing took place to Leamington and Coventry, when an enthusiastic party of members and friends enjoyed a social afternoon and evening. This Session's lecture programme opened in September when Mr. A. B. Waring gave a lecture on "Time, Space and Productivity". This meeting was not only a Midland Region meeting but also a joint meeting with the Birmingham Productivity Association, of which the speaker is a very active member, and there was a large and appreciative audience. A very lively discussion followed.

A full programme of lectures and Social events has been planned and the Section look forward to an enjoyable Session.

Birmingham Graduate

A number of meetings has taken place between the Registrars of Coventry, Wolverhampton and Birmingham Graduate Sections, with the object of encouraging other Sections to adopt a common system for the collection of data and a report has been published and distributed to all Sections.

Visits have been made to Lloyds (Burton) Ltd., and to Jury Holloware Ltd., where members saw among other things, the most modern vitreous enamelling plant in the country.

A lecture on "Abrasives" was given by Mr. A. C. Turner, Grad.I.Prod.E., G.I.Mech.E., in September. The Paper was illustrated by two short films dealing with the manufacture of artificial abrasive media, and the safety precautions in the use of grinding wheels. A lecture entitled "Lighting and Productivity" was given in October by Mr. I. F. Roper, A.M.I.E.E.

During the summer vacation a group of members and friends went on a tour (organised by the Birmingham Graduate Section) of Western Germany, with the object of seeing something of the post-war recovery of German industry. A Conference was held in Cologne at the end of the tour, and it is hoped that a report will be ready shortly.

Coventry

There has been little activity during the summer months, although the Committee have held a number of meetings at which applications for membership and transfer have been considered, and the appropriate recommendations made.

The Committee dinner for members and their ladies, which was so successful in 1953, was repeated this year with equal success.

The first lecture this session was given by Mr. F. Nixon on "The Effective Use of Materials". The lecturer had covered his subject very fully so that the discussion was somewhat briefer than usual. A venue for lectures has been arranged and a copy of the Midland Region Activities booklet has been sent to all members.

Coventry Graduate

During the quarter under review the Committee have been preparing this session's lecture and social programme. Members were asked to indicate their interests from a list of approximately 20 subjects covering a wide field. It is significant that subjects of a management and administrative nature form the greater part of Graduate interest in Coventry at the present time.

The first lecture of the session, "Public Speaking", by Mr. W. F. S. Woodford, was very well received by an audience which was larger than any achieved last Session. A car "Treasure Hunt", which has been a feature of recent social programmes, was held in September and was once more well supported.

Wolverhampton

The programme commenced in September with a Regional Meeting at which the 1954 Sir Alfred Herbert Paper "Some Problems of Higher Technological Education" was presented by the Rt. Hon. the Earl of Halsbury, F.R.I.C., F.Inst.P., at Wolverhampton & Staffordshire Technical College. On this occasion the Section were delighted to entertain Sir Walter Puckey, the President, and Mr. W. F. S. Woodford, the Secretary.

Mr. W. B. Pamment has resigned the office of Hon. Secretary following his new occupation necessitating considerable absence from Wolverhampton. Mr. R. J. Sury has been elected in his place.

Wolverhampton Graduate

A full programme has been arranged for the new Session, including nine lectures, and twelve works visits. The first lecture of the Session was held in September when a Paper was presented by Mr. W. J. Ford, M.I.Prod.E., Chairman of the Norwich Section, on "Pneumatic Aids to Production". This lecture was very interesting and very well attended. Also in September a visit was made to Messrs. Burman Gears Ltd., Coventry. A party of thirty Graduates and visitors travelled to the works by coach.

Committee meetings are held each month and a great deal of interesting work is carried out by the twelve Committee members. This year the Committee are convening the 5th Graduate Conference in March 1955. So that details can be attended to early and efficiently a Sub-Committee has been set up. Although previously the office of Social Secretary has been held by the Hon. Secretary, this year a Social Secretary has been appointed, Mr. B. McCloskey, and he has arranged the Graduates Dance to be held in October.

NORTH MIDLANDS REGION

Leicester

A full and interesting programme of lecture meetings has been arranged for the coming Session.

The Section Annual Dinner will be held in November and guests will include the Lord Mayor of Leicester, local industrialists and the Secretary and Education Officer of the Institution.

It is hoped to form a Student Centre at Loughborough College, and Mr. Sparling, who has been co-opted as a Section Committee member, is working with the College staff on the matter.

It was decided at the last Committee meeting that it was too late to include in this year's lecture programme, the recommendation that Sections should arrange discussion meetings following the publication of Research Committee reports, but it may be possible to arrarge for this in the future.

Lincoln

Members and friends of Lincoln Section visited the Works of Messrs. Firth Brown Tools Ltd., in June. The Section are very grateful to the Management for their kindness in allowing members to visit their works and for their hospitality.

The Section Committee have arranged a full lecture programme for the coming Session which they feel covers both the management and production interests of members. There will be five meetings in Lincoln, one at Scunthorpe and one at Newark.

A Dinner Dance has been arranged for October to be held at The Ruston Club, Lincoln.

Nottingham

During the summer months the Section has been relatively inactive, apart from three very successful works visits. The lecture programme promises to be interesting and has for its theme increased productivity. At the first meeting in October four speakers gave their "Impressions of Production Methods in the United States".

Peterborough

The 1954/55 programme shows an increased co-operation between this Section and other local organisations. A joint lecture meeting has been arranged with the Peterborough & District Group of the Institute of Cost & Works Accountants, when Mr. E. C. Gordon England is to present his paper entitled "Valid Incentives". Another joint meeting is being held with the Peterborough Branch of the Institute of Plant Engineers for a paper by Mr. R. A. Rogers of Hoover Ltd., entitled "Plant Maintenance and Productivity".

As a result of a suggestion that interest of younger members in Section activities might be stimulated if representatives of the Graduate Members were invited to attend Section Committee Meetings as observers, a number of this Section's Graduates have attended the past three Committee Meetings. The Committee considers that some of the points raised by these members are indicative of a very keen interest and it has been decided to continue the practice for future Committee Meetings.

NORTH WESTERN REGION

Liverpool Graduate

Since the Annual General Meeting the Committee have met on several occasions to arrange the Section Programme of lectures and works visits, and to plan for future activities; to explore ways to reduce the Section's expenditure and to carry out day to day business. The second Committee meeting of the Session was attended by Mr. J. France, the Senior Section Chairman, whose personal interest in the Graduate Section is most encouraging.

The Section have once again formed a Hazleton Memorial Library Panel of Members who are willing to review and compile abstracts from new library books.

A party of twenty-five members visited Messrs. Lockheed Hydraulic Brake Co. Ltd., Liverpool, in September. The visit was most instructive and well planned.

Manchester

A very interesting lecture programme has been prepared for the coming Session. The Committee would like to record their appreciation of the very excellent work which has been done in this connection by Mr. H. G. Gregory, Chairman of the Syllabus Sub-Committee.

It has been proposed by the Committee that a Regional Golf Match sponsored by the Manchester Section be held in the spring of next year, and any Regions situated near the North Western Region are invited to take part.

The arrangements for the Manchester Section Dinner are well advanced. It has been proposed by the Section Committee that the event be made a Regional occasion, and invitations have been issued to the Section Secretaries. It is hoped that other Sections will combine to ensure "Regional Success" especially as an invitation has been extended to the President, Sir Walter Puckey, to be Guest of Honour.

Applications for membership continue to arrive and the monthly average is being well maintained.

Mr. F. W. Cranmer, the Section's representative on the Local Productivity Committee has reported continued interest and activity in the interchange of works visits.

Manchester Graduate

The lecture programme for the 1954/55 Session was completed by the end of July, a series of six lectures being arranged. At least two of these are original lectures, namely "Rust, its Prevention and Removal" by Mr. F. S. Bricknill, and "Centreless Grinding" by Mr. T. Smith. A lecture on "The Electronic Control of Machine Tools" will be given by Mr. E. Hey.

As from July the Section have elected one member of the Committee to act as registrar. His duties will be to collect the data required as outlined at the Fourth Annual Graduate Conference held in Coventry earlier this year.

Preston

Arrangements for the winter Session of lectures have now been completed. There are five arranged by the Preston Section, and one Joint Regional Lecture to be held at Manchester. Of the five, three will take place at Blackburn, and two at Preston.

The Section is represented by members on the Local Productivity Committees at Bolton, Preston, Blackburn and Burnley.

Invitations to the opening lecture of the Session, "The Value of Work Study to Industry" to be given by Mr. W. H. Hodgetts, M.I.Prod.E., have been sent to the Secretaries of the above Local Productivity Committees and it is hoped that a useful and interesting discussion will take place.

NORTH REGION

North Eastern

The first Regional Committee Meeting was held in Durham in August, when plans were discussed for the Inaugural Meeting of the Tees-Side Section.

The North Eastern Section opened the new Session in September, when Mr. T. McCulloch gave his Chairman's Address to an appreciative audience. Also in September, the Inaugural Meeting of the Tees-Side Section was held. The President, Sir Walter Puckey, gave the opening address and an enthusiastic and large audience indicated that the Section was off to a healthy start.

Once again the North Eastern Section Committee have prepared a programme of great general interest and look forward to a successful Session. Already there are a number of new applications for membership under consideration and it is hoped to maintain this trend which has led to a steady increase in membership over the past few years.

Tees-side

A very successful Inaugural Meeting was held in September when the Address was given by Sir Walter Puckey. There were about one hundred people at the meeting and twenty-four Committee members and industrialists were afterwards entertained to dinner.

It is intended to hold four other meetings during the 1954/55 session and these are to be held alternately at Middlesbrough and Darlington.

NORTHERN IRELAND REGION

Northern Ireland

A very successful Works Visit was held in September, when a party of fifty members and their friends visited the Queen's Works of Messrs. Harland & Wolff Ltd. Members spent a most enjoyable and instructive three hours inspecting the huge diesel engines and turbines in various stages of erection and testing, prior to installation in one or other of the ships under construction at Queen's Island Shipyards, also the multitudinous valves and fittings etc., at the various stages of machining.

The lecture programme for 1954/55 is now almost complete, and details of the programme will be issued very shortly.

SOUTHERN REGION

Oxford

The new Session opened with a paper on "Some Aspects of Education in Production Engineering" given by Mr. H. Dodd, A.M.I.Prod.E., head of the Engineering Department of the West Oxfordshire Technical College, and a member of the Oxford Section Committee since its inauguration. As the Committee is anxious to stimulate interest in the activities of the Institution in the fringe areas of the Section, this meeting was held in Banbury, at the North Oxfordshire Technical College. The Principal, Mr. N. A. Pratt, A.T.D., welcomed those present.

The remainder of the programme for 1954/55 has now been arranged, and details are being circulated to all members of the Southern Region. Included in the programme are one lecture to be held in association with the Oxford Productivity Committee, and another to be held at Witney.

The July meeting of the Southern Region Committee was held in Oxford, and the local members of the Committee were happy to welcome members from Reading and Southampton, who were afforded the opportunity of touring the Morris Motors works during the afternoon prior to the meeting.

Reading

The support given by the Section for the Works Visits arranged to go over the Shell Haven Refinery in June and Ford Motors in September was very satisfactory. The visits were most enjoyable and interesting. The party were most impressed with the mechanised foundry and machine shop at the Ford Motors.

The Committee are looking forward to the coming Session of lectures which include several on work study, which it is felt will be of great interest to the Section.

Southern

The Section is now looking forward to another winter of lecture activities which will commence with a lecture entitled "Surface Finish" by Mr. J. Halliday, B.Sc. (Eng), in October. In November a lecture entitled "Provocative Tooling Methods for Aircraft" will be given by Mr. S. P. Woodley.

The highlight of the lecture programme will be a joint meeting to be held in December, in conjunction with the Southampton Branch of the Institute of Cost and Works Accountants and the Southampton Local Productivity Committee, when a lecture will be given by Mr. J. Dunning, B.Sc.(Econ.), of Southampton University, on "Impact of U.S.A. Financed Companies on Productivity in Great Britain", Sir Walter Puckey has kindly consented to visit the Section and take the Chair.

SOUTH EASTERN REGION

London

Naturally there has been little visible result of the work of the London Section Committee since the lecture Session did not start until 21st October.

During the past months a varied and interesting lecture programme has been developed and plans have been finalised for the Section Dinner-Dance which is to be held on 3rd December. Both Mr. G. R. Pryor and Mr. W. F. S. Woodford will be guests at this function but unfortunately the President, Sir Walter Puckey, cannot be present.

The resignation from the Section Committee of Mr. D. H. Mason is reported with great regret, but Mr. Mason is now permanently in the Midlands.

Mr. F. C. Cooke has been nominated as Section representative on the Papers Committee.

The Section Chairman, Mr. R. E. Leakey, served as Chairman at the London Graduates' recent weekend school.

Membership has continued to grow at a satisfactory rate.

Luton

The first lecture meeting of the 1954/55 Session was held in September. The Section Committee feels that the attractive lecture programme which has been prepared will interest all members. The Section has now reverted to the practice of sending notices to individual members of all lecture meetings, which appears to be one of the main factors in sustaining attendances at high level.

During the past few months, the Section has maintained close contact with the British Productivity Council, through the formation of a Luton Local Productivity Committee, and latterly, in Letchworth. In each case, the Institution has been represented at inaugural meetings, with liaison at later meetings.

SOUTH WESTERN REGION

Western

During the quarter under review the Committee has been occupied in arranging the next Session's programme, which at present gives promise of being a very interesting one. The first meeting in October was on "The Manufacture of Large Solid and Hollow Forgings", the Paper being given by Mr. R. W. Brocklehurst, M.I.Prod.E.

The Annual Dinner and Dance was held in October. Once again it was run as a Civic Function and the Lord Mayor, Lady Mayoress, the Sherriff and his lady attended.

WALES REGION

South Wales and Monmouthshire

The first Associate Membership examination to be held in Wales took place recently at Cardiff Technical College and this has certainly had the effect of increasing the interest in the activities of the Institution.

Mr. H. T. Jones, the Section Chairman, has recently visited Australia and he received a very warm welcome from the Melbourne Section and was invited to attend one of their meetings. Afterwards he was entertained to dinner by the Melbourne Committee and a very interesting discussion of Institution matters took place.

New Committee members elected are Mr. Bache, Mr. Graham-Falcon and Mr. J. Memingway. Mr. H. Dixon has been elected as a member of the Standards Committee and Mr. Hemingway to the Papers Committee as a Corresponding Member. Mr. E. G. Jones, A.M.I.Prod.E., has been elected as a member of the Cardiff Section of the British Productivity Council.

SECTIONS OUTSIDE THE U.K.

Adelaide

In June, Mr. J. S. Walker, B.Sc., Superintendent of Technical Education, S.A. Education Dept., gave a lecture on "Education for Industry". The July meeting was arranged as a joint meeting with the Australian Institute of Metals, and Mr. R. B. Muirhead read a Paper entitled "The Properties and Applications of Spheroidal Graphitic Cast Iron". The subject for the August Meeting was "The Mechanisation of Production Control and Industrial Records" by Mr. O. L. Wilson, A.C.A.A., A.C.I.S., and he illustrated his talk with a film describing the use of the various punched card machines.

A visit to a refrigerator factory was made in June, and members inspected the foundry, machine shop, and assembly.

Bombay

The three Committee Meetings held during the quarter dealt with the usual matters connected with the administration of the Section. Activities and Membership Sub-Committees for the current year were elected at the meeting that took place in September. Applications for membership continue to be received at a satisfactory rate.

The Annual General Meeting was addressed by the outgoing President, Mr. E. H. Y. Burden, and the elections of Mr. J. V. Patel as Section President, Mr. L. Gonda as Section Vice-President, and Mr. E. Fernandes, as Section Hon. Secretary/Treasurer for the ensuing year, were confirmed. The Committee for the year 1954/55 was also elected. At the conclusion of the Meeting a film entitled "Powered Flight", dealing with the history of the development of the aeroplane in England up to present times, was shown to an interested audience.

The September General Meeting was addressed by Mr. D. B. O'Kain who is in charge of the construction of the Burmah Shell Oil Refinery in Bombay. In spite of this day being completely representative of Bombay's wettest monsoon on record, about 60 members and visitors heard a very interesting paper on the methods adopted in "The Handling and Erecting of Heavy Pressure Vessels in Oil Refineries". The Meeting was rounded off with a film entitled "Men and Oil", which showed the passage of crude oil through a Refinery, and the people who run the industry.

Calcutta

Only two Committee Meetings were held during the quarter under review, to deal with the applications and other business.

In September Sir A. K. Chakraburty, Factory Inspector, read a Paper on "Industrial Safety and Laws." His Paper was well received and was followed by a lively discussion.

In August, Mr. N. N. Sen Gupta, M.I.Prod.E. attended, on behalf of the Institution of Production Engineers, a meeting of the Sub-Committee of the Ministry of Education, Government of India, for the establishment of a National Institute of Management in India.

The second meeting of the All-India Board of Technical Studies on Management was held in New Delhi in September. Mr. N. N. Sen Gupta, M.I.Prod.E., attended the meeting as representative of the Institution of Production Engineers in the temporary absence of Mr. B. F. Goodchild, Chairman of the Calcutta Section, who had left India.

Canada

The Committee have continued to meet but there are no Section activities during the summer months. Section meetings commence next month with a visit to the Anaconda American Brass Company at New Toronto.

Melbourne

Sections meetings are still being well attended. The July meeting was combined with that of the Institute of Metals (Aust.) when a Paper entitled "Metallurgical Aspects of Production Planning" was given by Mr. Ken Hartnell. At the conclusion of the meeting a vote of thanks was given to the lecturer and to the Institute of Metals by the Section Chairman, Mr. H. G. Sutton.

In July, a Works Visit was held when members were the guests of McPherson's Ltd. to hear a lecture and demonstration on "Shell Moulding" by Mr. J. Fallows. During August, Mr. H. T. Jones, M.I.Prod.E., Wales Regional Chairman, and Chairman of South Wales Section was entertained by the Section Chairman and office bearers. Mr. Jones was also welcomed to the meeting in August when a Paper entitled "The Control of Engineering Production" was given by Mr. A. G. Jones.

At the meeting in September a Paper was given on "Australian Development of Metal Bonding Processes for Aircraft Structures" by Messrs. G. D. Bennett, B.Sc.(Eng.), A.C.G.I., D.I.C., A.F.R.Ae.S., and D. Sibley, both of Government Aircraft Factories. Following this Paper forty members were the guests of the Government Aircraft Factories at Fishermen's Bend in September.

South Africa

At the General Meeting of the Branch held in July Mr. H. Thompson delivered a Paper entitled "The Transmission of Power by means of Friction Clutches with Particular Reference to the Pneumatic Clutch". In September a Paper on "Engineering Metrology" was presented by Mr. J. A. Baty.

The Annual General Meeting and Dinner of the S.A. Branch was held in August. At the meeting some 141 members and guests were present, which constitutes a new record for attendance at the function.

Mr. W. G. Gillespie was re-elected President of the S.A. Branch for the year 1954/55. This is the first occasion, since the establishment of the Branch in 1943, on which the President has been in office for two consecutive years.

Sydney

A visit to the works of W. E. Sykes was arranged in June and 70 members enjoyed a lecture and demonstration on Shell Moulding by the Polygram Casting Company of U.K. During the quarter under review, Mr. W. I. Miskoe presented a Paper entitled "Production Welding". Mr. Miskoe illustrated his lectures with slides showing various application and the possibilities of modern welding techniques and their challenge to the ingenuity of the production engineer.

In August Mr. N. A. Esserman, B.Sc., M.I.Prod.E., F.Inst.P., A.M.I.E. (Aust.) presented a paper on "Production Measuring Equipment" and an active discussion followed. The last lecture of the season was given in September by Mr. H. Grafton, Dipl.Ing., A.M.I.Prod.E., on "The Significance of Machine Tools in the Australian Economy". Mr. Grafton is a lecturer in Production Engineering at the New South Wales University of Technology.

SOCIETY OF VISITING SCIENTISTS

The attention of members is drawn to the Society of Visiting Scientists, which was established in 1944, when Britain had the honour of welcoming many scientists from allied countries. The Society seeks to be a focus for all scientists visiting the United Kingdom, and to put them in touch with British scientists and with one another, and by this means to provide and encourage an active exchange of scientific thought and discussion.

Further information about the work of the Society, and particulars of application for membership, may be obtained from the Assistant Secretary, Society of Visiting Scientists, 5, Old Burlington Street, London, W.1.

JOURNAL BINDERS

Members are advised that binding cases for the Journal are available, and may be ordered from Head Office. The cases, which are strongly made and covered in dark red leather cloth, with "The Institution of Production Engineers Journal" in gilt on the spine, will each hold 12 copies of the Journal. The price per case is 10/-, post free.

OFFICIAL OPENING OF NEW HEADQUARTERS

28th OCTOBER, 1954.

NEARLY every Section of the Institution in the United Kingdom was represented when the new headquarters of the Institution were officially opened on Thursday, 28th October, 1954, by the President, Sir Walter Puckey. Sections outside the U.K. sent greetings and good wishes.

Among those who attended were the heads of many companies who have made generous donations to the New Building Fund, and the Presidents of kindred associations, together with some of the Institution's many friends among the national and technical Press.

The opening ceremony was to have been performed by Sir Leonard Lord, K.B.E., Chairman and Managing Director of The British Motor Corporation, Ltd., and Vice-President and President-Elect of the Institution, but he was unfortunately unable to attend because of illness. In a message to the President, expressing disappointment that he was unable to be present, Sir Leonard said: "Will you, as President, accept my very best wishes for the future of the Institution in the new premises. I feel sure that it will continue to go forward successfully as it has always done".

In declaring the premises open, Sir Walter Puckey paid tribute to all those who had made the opening possible. He expressed the thanks of Council to all those members and friends who had responded to the New Building Fund Appeal, which had been launched by his predecessor in office Sir Cecil Weir.

Sir Walter also thanked the Institution Architect, Mr. C. H. Brightiff, who had been in charge of the work of preparing the building for the Institution's use, and in particular he thanked Lady Sempill, who had been the Institution's advisor on interior decoration. She had ensured that the period features of the house had been restored to their full beauty. To mark the Institution's appreciation, the President made a small presentation to Lady Sempill.

The President also expressed the Institution's thanks to the permanent staff for their enthusiasm and hard work in setting up the new headquarters.

Mr. J. D. Scaife, a Founder Member and Past President of the Institution, also gave a short address, in which he recalled the formation of the Institution 33 years ago, and its several homes since that date. It gave him personally keen satisfaction, and he was sure that this feeling was shared by those other members who had watched and assisted the growth of the Institution from its early and sometimes difficult years, to see the Institution at last housed in a permanent and eminently suitable home.

A commemorative brochure, giving a brief history of the Institution and containing photographs of the new headquarters, was prepared for the occasion, and is reproduced in the following pages.

NEW BUILDING FUND APPEAL

Since the publication of the last list, donations have been received from the following subscribers. (The list was compiled for press on 18th November, 1954.)

D. T. Amos, Grad.I.Prod.E.
Adelaide Section.

Birmid Industries Ltd.
British Motor Corporation Ltd.
T. Brown, Stud.I.Prod.E.

Cincinnati Milling Machines Ltd.

L. J. Doughtrey, A.M.I.Prod.E.

T. W. Elkington, M.I.Prod.E.

F. Gale, Grad.I.Prod.E.
E. H. Godwin, M.I.Prod.E.

A. W. Hallpike, M.I.Prod.E.
E. J. Hunter, Stud.I.Prod.E.

J. Keightley, Grad.I.Prod.E.

Liverpool Graduate Section:-

Colin Copeland, Stud.I.Prod.E.
I. E. Crisp, Grad.I.Prod.E.
H. H. Cushing, A.M.I.Prod.E.
Alan G. French, Stud.I.Prod.E.
B. P. Hague, Grad.I.Prod.E.
G. K. McNair, Grad.I.Prod.E.
T. N. Parr, Stud.I.Prod.E.
J. Robinson, A.M.I.Prod.E.
G. L. Smith, Grad.I.Prod.E.
R. T. Spencer, Grad.I.Prod.E.
A. J. Vine, Grad.I.Prod.E.
D. Whitehead, Grad.I.Prod.E.

L. McPherson, Grad.I.Prod.E.
C. A. W. Morgan, A.M.I.Prod.E.
J. F. Mullervy, Grad.I.Prod.E.
R. B. Myring, Stud.I.Prod.E.

A. G. Pate, A.M.I.Prod.E.
H. G. Peglar, A.M.I.Prod.E.
Marshall G. Pobjoy, A.M.I.Prod.E.

Reavell & Son.
P. Robinson, Stud.I.Prod.E.
A. A. Ryall, Grad.I.Prod.E.

H. M. Sawyer, M.I.Prod.E.
C. T. Seymour, A.M.I.Prod.E.
South Wales Section, Members of

R. Telford, A.M.I.Prod.E.
A. C. Trubshaw, M.I.Prod.E.
R. H. J. Tyson, Grad.I.Prod.E.

D. J. White, Stud.I.Prod.E.
W. T. White, A.M.I.Prod.E.
C. Wollaston, M.I.Prod.E.

Reproduced from the brochure prepared to commemorate the official opening of the Institution's new headquarters on 28th October, 1954.

THE INSTITUTION HEADQUARTERS

The Inaugural Meeting of the Institution of Production Engineers was held at the Cannon Street Hotel, London, on 21st February, 1921. The Headquarters was established in London, but in the earlier years of its existence it had no regular offices or permanent staff; the administrative and secretarial work being carried out by members on a voluntary basis. Mr. E. D. Ball held the office of Institution Honorary Secretary until May, 1929.

In those days the Institution funds were insignificant and a good deal of the expenses were met out of members' own pockets. It was the usual practice after committee meetings for members present to subscribe to the cost of hiring the room.

In 1929 Council decided to appoint a full-time official and Mr. Richard Hazleton took office as General Secretary of the Institution on 18th May, 1929. Following this appointment the Institution acquired its first Head Office, which constituted one small room at 48 Rupert Street, London, W.1. At that time the membership had reached 250. This was the Institution's home for only a short period, for in August, 1930, the Head Office was moved into two rooms at 40, St. James Street, Bedford Row, London, W.C.1.

The St. James Street offices proved adequate for a while, but the steady growth eventually made another move necessary, and a small suite of offices was rented at British Industries House, Oxford Street, London, W.1, in January, 1935. By this time the staff had increased to five in number and the total membership of the Institution was 1,200.

It became apparent, however, that the time was not far off when Headquarters of a more permanent character would be needed. In 1938

a generous gift from Lord Nuffield, who was then President of the Institution, enabled the lease of 36, Portman Square, London, W.1, to be acquired. The house provided not only more than adequate accommodation for the Secretariat but also enabled a Library to be established and rooms for meetings of Council and committees. This building was badly damaged by enemy action in 1944 and for a few years the Institution occupied temporary and very cramped premises at 10, Seymour Street, London, W.1.

In recognition of the importance of the Institution's work, however, H.M. Government granted licences for the reconstruction of the Headquarters and 36, Portman Square was re-occupied in June, 1948. At that date the membership totalled 7,300 and the permanent staff numbered 30. This rapid expansion during a comparatively short time made it obvious that 36, Portman Square offered little room for future expansion. Then the Institution was informed that the lease was unlikely to be offered for renewal when it expired in a few years' time, so Council decided that the Institution should acquire, as soon as possible, permanent Headquarters. It is significant that in the few years since the Council made this decision the membership has increased to 10,000.

The problem, however, was to find a building which whilst being adequate for some time to come, was yet offered at a price which the Institution could afford. After two years' careful exploration Council had the good fortune to acquire the freehold of 10, Chesterfield Street, London, W.1. The purchase was negotiated by Mr. Lionel Brown, who also negotiated with the Town Planning Authorities who have granted the Institution a licence to use the building for the Institution's purposes in perpetuity.

Chesterfield Street was built in 1756-7 and was so called because it

(continued on page 720)

The Entrance Hall

The Entrance to the Council Chamber

The Council Chamber

One of the ceiling panels in the Council Chamber

Part of The Hazleton Memorial Library

formed the Eastern boundary of the gardens of Chesterfield House, which was a mansion erected by Isaac Ware in 1749 for Philip, fourth Earl of Chesterfield. This mansion has since been demolished to make way for a block of flats.

" Beau " Brummell arranged, with great elegance, his bachelor establishment at No. 4 Chesterfield Street on his retirement from the Army in 1798. During his residence there he was in full enjoyment of the Royal favour and was frequently visited by the Prince of Wales, who would drive up from Carlton House in the morning to be present at the toilet of this arbiter of fashion. No. 1 became a few years later the residence of John William Ward, fourth Viscount Dudley and Ward ; this nobleman served under the Duke of Wellington at the Foreign Office. No. 3 was the house for more than thirty years of the poetess Caroline Norton, one of the three beautiful daughters of Richard Brinsley Sheridan ; while at No. 11 resided until his death in 1855, Sir Robert Adair, the distinguished diplomat and close friend of Charles James Fox.

It appears from historical records that Number 10 Chesterfield Street was erected in approximately 1760, and was occupied by a Mr. John Walsh until 1795. During the period 1796-1798 it seems that the house was enlarged and considerable structural alterations took place.

Subsequently the following were the occupants of the house :

1798–1805	John Sullivan
1806–1835	Thomas Snodgrass (believed to be the Thomas Snodgrass mentioned in Dickens' " Pickwick Papers ")
1835–	Miss Russell
1836–1873	Robert Staples
1874–1903	Viscount Hood (grandson of the famous Admiral)

1904–1910	Viscount Lee of Fareham (who presented " Chequers " to the nation as a country residence for the Prime Minister)
1911–1920	Wm. Lockett Agnew, J.P.
1921–1929	Chas. Vincent Sale
1930–1931	Unoccupied
1932–1939	Earl Fitzwilliam
1939–1953	Requisitioned by the Government
1954– ?	The Institution of Production Engineers.

The house as it stands today is solidly constructed and large enough to provide room for future expansion of the Institution. It contains several period features including work attributed to Robert Adam. The paintings on the ceiling in the Council Chamber are attributed to Angelica Kauffman.

When the building was first inspected by the Institution officers it was in a dilapidated state, although fortunately the structure was in first class order. The work of restoration was entrusted to a House Committee composed of the President, Sir Walter Puckey ; and two Past Presidents, Lord Semphill and Major-General Appleyard. The House Committee and the Council of the Institution are greatly indebted to members and Companies who have subscribed to the New Headquarters Appeal Fund. These generous donations amounting in total to over eleven thousand pounds have gone a long way to make the work of restoration possible. The Council are also extremely grateful to Lady Semphill for her invaluable help and advice in the decoration and furnishing of the entrance hall and public rooms. The building contractors were under the supervision of the Institution Architect, Mr. C. H. Brightiff, F.R.I.B.A. The acquisition of the property was a very important step forward for the Institution and is a sign of the remarkable progress which it has made since its foundation in 1921.

The Institution desires to express appreciation to the Clerk to the London County Council for permission to reproduce the photographs of the entrance to the Council Chamber and one of the ceiling panels in the Chamber itself.

PAPERS FOR PUBLICATION

The attention of members is drawn to this article by the Chairman of the Institution's Papers Committee.

THE Papers Committee would like to think that it is the aim of every member of the Institution to contribute at least one Paper during the period of his membership and accordingly invites the submission of Papers to be considered for publication in the Journal. The Journal is the strongest link between the Institution, as a corporate body, and its individual members; it is therefore very important that it should contain as much as possible that will contribute to the science, art and practice of production engineering, and it is in this field that members can perform a very valuable service.

A cordial invitation is also extended to specialists in other fields which have a bearing on production engineering, to widen the scope of knowledge available to readers of the Journal by presenting Papers on their own subjects.

The main source of supply of Papers for the Journal is from Section and Regional meetings and it is desirable that as many Papers as possible, presented to these meetings, should be written in a form suitable for publication. It may be that some Authors would be prepared to write a Paper which, for various reasons, would not be presented at a meeting but which may well be suitable for publication: such Papers are very welcome and will be given full consideration.

Experience has shown that a Paper which has been written in full, prior to being read at a meeting, is usually preferable to one which has been expanded from brief lecture notes. Authors' opinions will no doubt vary widely on this point but it will be obvious that, where a lecture has been built round projected illustrations or demonstrations, particular care will be needed to see that adequate explanations are given, where necessary, in the text.

It is suggested, also, that intending Authors would find it helpful if they could decide clearly, before starting work, whether their aim is to produce a lecture, or a more formal Paper, as there are naturally essential differences in the treatment of the material in each case.

Every Paper submitted is considered by the Papers Committee of the Institution and is independently assessed by several members of the Committee. The Committee is composed of a number of elected members, together with a larger number of corresponding members who are nominated by Sections. It is the policy of the Committee to ensure that each Paper is assessed, not only by an expert in the subject of the Paper, but by others who will read it from the point of view of the non-specialist member.

Institution Awards for Papers

The Institution makes three Annual Medal Awards from Papers presented to Sections. The awards are made for :-

(a) The best Paper presented to a Section by a Member;
(b) The best Paper presented to a Section by a non-member;
(c) The best Paper presented to a Section by a Graduate member (The Hutchinson Memorial Award.)

A pamphlet entitled "Notes for the Guidance of Authors Preparing Papers for Presentation to the Institution" is issued by the Institution. Anyone considering the presentation of a Paper is invited to write for a copy, either to Head Office or to his Local Section Honorary Secretary.

Several publications dealing with the preparation and presentation of Papers are also available on loan to members from the Hazleton Memorial Library, as follows :-

PUBLIC SPEAKING

CRAWFORD, Archibald. "Mind Training for Speech-Making." *London, Pitman*, 1947. 136 *pages.*

GOUGH, Vera. "Speaking is your Business." *London, Bell*, 1953. 127 *pages.*

HOFFMAN, William G. "How to Make Better Speeches." *New York, Funk & Wagnalls*, 1948. 266 *pages.*

WILLIS, A. H. "The Technical Lecture: a guide to authors and chairmen." *Sydney, Quest Publications*, 1953. 64 *pages.*

TECHNICAL WRITING

AGG, Thomas R. and FOSTER, Walter L. "Preparation of Engineering Reports." *New York, McGraw-Hill*, 1935. 192 *pages.*

GLOAG, J. "How to Write Technical Books, with some pertinent remarks about Planning Technical Papers and Forms." *London, Allen & Unwin*, 1950. 159 *pages. Illustrated. Diagrams.*

GOWER, Sir Ernest. "The Complete Plain Words." *London, H.M.S.O.*, 1954. 215 *pages.*

INSTITUTE OF COST AND WORKS ACCOUNTANTS, London. "Presentation of Information to Management." *London, the Institute*, 1950. 49 *pages.*

KAPP, Reginald O. "Presentation of Technical Information by R. O. Kapp . . . Based on . . . lectures . . . at University College, London. *London, Constable*, 1948. 147 *pages.*

NATIONAL PHYSICAL LABORATORY, Teddington, Middlesex. "Inclusion of Equivalent Metric Values in Scientific Papers." *London, H.M.S.O.*, 1948. 15 *pages.*

NELSON, J. Raleigh. "Writing the Technical Report." 2nd edition. *New York, McGraw-Hill*, 1947. 388 *pages.*

OLIVER, Leslie M. "Technical Exposition: a textbook . . . for students of engineering." *New York, McGraw-Hill*, 1940. 193 *pages.*

RHODES, Fred H. "Technical Report Writing." *New York, McGraw-Hill*, 1941. 125 *pages.* (Chemical Engineering Series.)

MATERIALS HANDLING CONFERENCE

BIRMINGHAM, 23rd OCTOBER, 1954.

THE Materials Handling Conference organised by the Materials Handling Sub-Committee of the Institution's Research Committee, and held at the works of John Wright Limited, Birmingham, on 23rd October last, was attended by 240 members and guests. Among the prominent personalities present were the members of the French Productivity Mission; Mr. Gregory Meakin, of the Federation of British Industries; Principal Wilson, of the Birmingham College of Technology; Mr. Bramley Harker, H.M. Superintending Inspector of Factories; Mr. Hopps, of the Birmingham Industrial Safety Group; and representatives of the Institution of Mechanical Engineers, the Institution of Industrial Administration, the Institute of Cost and Works Accountants, the Institution of Works Managers, and the Institute of Industrial Supervisors.

Mr. Ivar Yates Chairman of John Wright, Limited (the Birmingham Productivity Centre of Radiation, Limited) welcomed the delegates and introduced Mr. Bond-Williams, Chairman of the Birmingham Productivity Council, who referred to the importance of reduction of handling time and handling costs if "the Americans were to be beaten at their own game". Speaking of the old concept of "floor to floor time", he suggested that this would be better known as "bin to bin" or "pallet to pallet" time, or, better still, "tool to tool" time.

Mr. Bond-Williams was followed by Mr. B. G. L. Jackman, Chairman of the Birmingham Section of the Institution. Mr. Jackman, after congratulating the Materials Handling Sub-Committee on its work during the four years since its inception, referred to the Anglo-American Productivity Reports, which

The Conference in session.

showed that movement of materials within a factory could account for up to 40% of production costs Reduction of this figure was vitally important.

After coffee the delegates were conducted, in small groups, round the works of John Wright, Limited, and subsequently an excellent luncheon was provided in the Works Canteen.

After luncheon, the Chairman of the Materials Handling Sub-Committee introduced the four speakers, whose subjects were :-

"Bringing the Materials to the Works" by J. H. Vine, Head of the Terminal Research Department, British Railways, Western Region.

"Bringing Material to the Work Station" by L. J. Hoefkens, Stores Controller, Lockheed Hydraulic Brake Company, Ltd.

"Handling at the Work Station" by J. B. Jay, Manager, Automation Division, Hymatic Engineering Company, Ltd.

"Removal of Job, Swarf and Scrap" by W. M. Hiorns, Humber, Ltd.

After a valuable discussion, Mr. Harold Burke, Past Chairman of Council of the Institution, and Chairman of the Midland Regional Committee, in summing up, referred to materials handling as "a problem with which we are all faced and about which we cannot afford to be very clever; none of us has the complete answer". He emphasised the important part which improved materials handling can play in increasing productivity in small and medium sized firms, to whose problems, indeed, the main force of the Conference had been directed.

"In the long run" said Mr. Burke, "we come inevitably to the stage where we ask ourselves where this country fails in comparison with America", and he concluded that the answer lay in the methods that the Americans applied to manufacture. The Materials Handling Sub-Committee was trying to make available information which would help British industry to apply improved methods.

Mr. Ivan Yates, Chairman of John Wright, Ltd., welcomed the delegates and introduced Mr. Bond-Williams, Chairman of the Birmingham Productivity Council (seated right). Also on the platform are (from left) Mr. T. W. Elkington, Mr. Harold Burke, Mr. H. P. Slade (Director and General Manager, John Wright, Ltd.,) and Mr. B. G. L. Jackman.

In conclusion, the Chairman moved a vote of sincere thanks to the speakers, which was carried by acclamation. He also expressed to Mr. Yates and to his Company, the Institution's warm appreciation of their hospitality.

The Conference concluded at 5.30 p.m., after a successful and interesting day.

"EDUCATION AND RESEARCH FOR PRODUCTION" *(concluded from page 662)*

firms (who can hold their own with anybody in the world) in raising themselves to their high level have recognised the claim on their resources, in no small way, for education and training both within and without their own organisation.

The direct participation of industry in this way is invaluable in promoting productivity by one means or another. The productivity that comes from capital investment may be outside the range of many, but the improvement in the productivity level which comes from the better use of existing resources, human and material, is within the reach of all. The problems to be solved must however first be identified. These are often hidden beneath obsolete practices, to be brought to light only by systematic study of the actual industrial processes, the handling of materials and the layout of plant, through technical surveys, work measurement, motion and methods study. The exploitation of this vast field can be very remunerative and the rewards are to be had at no great cost. At least one of our largest firms passes all its managers through its own work study school, and, in addition to industry's own schemes, courses in management training are now provided by over 70 technical colleges and several adult education centres, whilst some of our Universities are pioneering a new line of approach.

The scientific and educational problems of production present a sharp challenge we cannot ignore. The efforts now being made to graft on our educational system a structure of such character and strength as to provide industry with sufficient people to exploit scientific knowledge and keep pace with technological advance is an encouraging sign of the times. We should, however, keep an eye on the foundations and not weaken in promoting knowledge of the natural laws and in gaining understanding of the nature of things. A desire to get quick results by preferring technicalities to fundamentals cannot lead to any good and there is little doubt that the teaching of technology must be rooted in fundamental science if it is to have any roots

FIRST YORKSHIRE REGIONAL GRADUATE WEEKEND SCHOOL

THE Third Annual Weekend School, which has hitherto been a Halifax Graduate function, was this year, for the first time, held on a Yorkshire Regional Graduate basis (writes the Chairman of the Weekend School Sub-Committee, Mr. G. Harrison).

The School was held on the 18th and 19th of September at the Craiglands Hotel, Ilkley.

We were fortunate enough to have with us the Chairman of Council, Mr. G. R. Pryor, who, besides opening the School, gave some helpful advice on the subjects to be discussed.

Since the School was Regional, the representative Sub-Committee decided to have the sessions under the Chairmanship of the Regional Sections in turn; unfortunately the Yorkshire member, Mr. J. Freel, was unable to attend, his place being filled at short notice by the Halifax Graduate Section Chairman, Mr. J. Taylor.

The School commenced on Saturday afternoon, with an attendance of thirty-two; the Chairman was Mr. E. Willcox, of the Sheffield Graduate Section, who introduced Mr. Pryor to the assembly.

In his opening remarks, Mr. Pryor said that whilst it was important to have a comprehensive knowledge of the science of engineering in its modern aspect, it was also very essential that we should have efficient leadership by people who were fully aware of the functions to be discussed over the weekend, and also of the problems of the approach to human relations; people, in fact, who realised to the full that they were dealing with human beings.

Applications of Work Study

The first lecturer was Mr. B. C. Hilton, of Messrs. Urwick Orr and Partners, who spoke on "Some Applications of Work Study", a subject which has been discussed many times before. On this occasion it took on a new and fascinating appearance, and Mr. Hilton confirmed what had been said earlier with regard to human relations.

Another important point made was one which must have cleared up a long-standing doubt in many minds, that work study did not necessarily mean buying a mass of new plant. The efficient work study man should, initially at any rate, utilise the plant at his disposal. Also, it was not always imperative to concentrate on speeding everything up; Mr. Hilton quoted one instance where there was a surplus of machines, and by slowing an operation down somewhat, an operator was able to work two machines and thus show an ultimate increase in production.

Mr. Hilton's lecture was followed by a lively and extremely interesting discussion.

Standard Costs and Budgetary Control

The second session, with Mr. Taylor in the Chair, proved to be of such proportions and interest that it was unanimously agreed to carry on after dinner.

The speaker in this instance was Mr. F. H. Pritchett, also of Messrs. Urwick Orr and Partners, who spoke on "Standard Costs and Budgetary Control".

This subject was a natural sequel to work study and at the end we were certainly more conscious of the importance of accurate cost control, the intricacies of annual budget forecasting and the correct allocation of overhead charges. This is most certainly a subject into which the young production engineer should delve very deeply, with a view to becoming conversant, and able to deal with, its many problems.

Case Study

Sunday morning saw the School reassemble to work on a Case Study which incorporated much of the knowledge imparted in the preceding sessions. This Case Study was based on an actual problem which had been solved some time before by the speakers. It was with great satisfaction that at the end of the session the solution reached conformed reasonably with the original.

Mr. J. Hepper, of the Halifax Graduate Section, had occupied the Chair for this rather tricky session.

The weekend's work was summed up by the School's Sub-Committee Chairman, Mr. G. Harrison, who also thanked the speakers for their work.

Those present at the School were pleased to have the opportunity of meeting Mr. H. Wyndham Badger, the Institution's new Education Officer.

This type of function has once more proved to be both popular and informative and, it is hoped, will be the first of many Regional Schools in the future.

LONDON GRADUATE SECTION WEEKEND SCHOOL

(concluded from page 726)

cess of artistry in design must be continuous, and that it was bad policy to apply the artist's brush at the final design stage in an attempt to achieve a product of pleasing appearance.

Following this discussion, the summing-up was ably performed by Mr. H. Peter Jost, Member, and the School closed with a vote of thanks to all those who had contributed to the success of the weekend, especially to those who were directly responsible for organising the programme.

LONDON GRADUATE SECTION

WEEKEND SCHOOL

THE London Graduate Section held its Annual Weekend School on 2nd and 3rd of October last. The following report has been prepared for the Journal by a member of the Graduate Section, Mr. D. C. Howard.

Following a now established tradition, the London Graduate Section held its 5th Weekend School on 2nd and 3rd October at Beatrice Webb House, near Dorking in Surrey. The theme this year was " Design for Production " and the School was presided over by Mr. R. E. Leakey, Chairman of the South Eastern Region and of the London Senior Section.

Material Utilisation

The proceedings commenced at 2 p.m. on Saturday, when Mr. F. E. Butcher, Group Design Manager with J. Lucas (Electrical) Ltd., gave the first lecture on " Material Utilisation ". He dealt with methods of working materials, considerations in plant utilisation and economies to be made by studying the process materials used during manufacture. These points were illustrated by some excellent examples, particularly of the use of aluminised plastics.

Great stress was laid upon the importance of establishing what the speaker termed " irrefutable " costs which must be used when making a comparison of materials and processess. He also expressed the view that there was need for firms to set up Product Teams for each product to be manufactured. He criticised designers for not being sufficiently ' production-minded ' and pointed out that the promotion of good ideas in new ways of utilising materials could be gained by both designers and production personnel visiting other industries. Some excellent samples from the toy industry illustrated this point.

During the discussion which followed it was agreed by the School that cost estimates must be unchallengable, as these were the basis of comparison. Another view was that, in the main, there was insufficient time for the design and production people to get a design thrashed out before it had to go into production.

Standardisation and Simplification

The second lecture was given by Mr. Ponton, Design Standards Engineer of Rolls-Royce, Ltd., Derby, who dealt with " Standardisation and Simplification ". Under this heading five main aspects—Parts, Methods, Materials, Processes and Flexibility —were considered. He pointed out that the main purpose behind simplification of design was the development of a product which could be easily used by the consumer as well as the simplification of its manufacture.

One main point which was brought out in discussion was the need for a greater interchange of ideas and for an extension of the work of the British Standards Institution.

Design and Production

In the third lecture Mr. G. W. Hart, General Manager of the Electronics Division of Murphy Radio, spoke on " Liaison between Design and Production ", and stressed the real need for both the design department and production department to get together right at the outset of a project. He considered also how this vital liaison could be brought about, emphasising that it should be promoted by management and not left to chance. Management could help both departments by engaging suitably qualified and experienced staff, and Mr. Hart suggested that all design staff should have learned something of production engineering from the factory floor.

During discussion the Lecturer endorsed the view of the School that large committees of design and production staff were a bad thing, as they tended to be too much at variance and liable to evade their individual responsibilities. Liaison, he felt, worked best when management invested responsibility in one man.

Appearance of the Product

Mr. J. Beresford-Evans, in the fourth and final lecture, considered on a very broad basis " The Study of Appearance during Design and Development ". Solidity, simplicity and eye-appeal he thought were the main points in a good design. He showed, with some first-class sketches, how artistry, style and fashion were related to design. This stimulated much interest and during discussion the question of making designers more " shape conscious " was raised. It was suggested that pleasing shapes often meant easier production.

Another point raised was the advisability of having consultant designers as against staff designers. It was suggested that although staff designers easily went ' stale ' unless they frequently examined types of products other than their own, consultant designers usually took some time to get used to a firm. In any case, so far as design was concerned, it was strongly recommended by the Lecturer that the pro-

(concluded at foot of page 725)

THE LORD AUSTIN PRIZE

Among the awards offered annually for competition among members of the Institution is the Lord Austin Prize. Its founder, the late Lord Austin, who was President of the Institution from 1931 to 1933, gave £100 for the foundation of the Prize and this sum was subsequently considerably augmented by the Austin Motor Company, Limited; the value of the Prize for the year 1954/55 will be £17 10s. 0d.

The Prize may be utilised to defray all or part of the cost of attendance at a conference, summer school or short course which will assist the recipient to further his career in production engineering. The prizewinner is free to decide how to utilise his Prize subject only to approval of his project by the Institution. Advice and guidance on this point will be willingly given on application to the Institution.

A Certificate is also presented as a permanent memento of the Award.

Essays submitted for the Prize are assessed under the following headings :-

Evidence given of the importance of the subject to production;

Content (technical/managerial);

Planning (logical development of the subject);

Style;

References, illustrations, charts, graphs, etc.

Apart from the monetary value of the Prize, success in a competition of this nature is a marked achievement which may well be of considerable assistance to a young man in his future career.

The conditions for the 1954/55 Award are :-

1. All Graduates of the Institution under the age of 30 years may compete.
2. Essays may be submitted on any subject within the field of production engineering. Before candidates begin preparing their essays, titles and brief synopses must be sent for approval to the Secretary of the Institution, to reach him not later than 1st March, 1955.
3. Essays should be not less than 2,000 nor more than 4,000 words in length.
4. Completed essays must be submited by 30th April, 1955, and should be sent to: The Secretary, Institution of Production Engineers, 10, Chesterfield Street, London, W.1.

PRODUCTION EXHIBITION ESSAY COMPETITION

It will be recalled that the Institution held an Essay Competition in conjunction with the Production Exhibition and Conference held at Olympia last July.

Essays were invited from students and others under the age of 21 years who visited the Exhibition or attended the Conference, and who were contemplating or had commenced a career in industry. The subject was to be chosen from what had been learned from the Exhibition and Conference.

The Institution now announces the names of the prizewinners in this Competition. In Group 1 (for candidates under the age of 18), the number of entries was so small that it was found possible to award a First Prize only, of £10 10s. The winner is K. Butler, aged 17, of 18, Lakehall Gardens, Thornton Heath, Surrey.

In Group II (for candidates between the ages of 18 and 21), a 4th Prize was added, and the amount of the awards increased, in view of the fact that the 2nd and 3rd Prizes were not awarded in Group I. The results are as follows :-

1st Prize (£12 10s. 0d.) to R. Woolston, aged 19, of 44, Morton Gardens, Wallington, Surrey.

2nd Prize (£7 5s. 0d.) to J. M. Sweet, aged 20, of 72, Oak Hill Crescent, Woodford Green.

3rd Prize (£3 10s. 0d.) to G. Goldsack, aged 18, of 348, Lower Addiscombe Road, Croydon.

4th Prize (£1 15s. 0d.) to A. R. Griffiths, aged 20, of 35, North Lane, Aldershot.

Mr. Griffiths is a student at the Royal Aircraft Establishment, Farnborough, and Mr. Sweet is studying at Enfield Technical College. All the other prizewinners are students at Croydon Polytechnic.

The President-Elect

Members will learn with pleasure that the next President of the Institution will be Sir Leonard Lord, K.B.E., Chairman of The British Motor Corporation, Limited.

Sir Leonard's outstanding qualities of leadership and administration, together with his reputation as a production engineer in the motor industry, are sufficient to commend him to the membership. Although his many business commitments may prevent him from taking part in as many Institution activities as he wishes, he has already shown a lively interest in the affairs of the Institution, as is evidenced by his Company's recent generous donation of £5,000 to the New Building Appeal Fund.

Melbourne Section's New Chairman

At the Annual General Meeting of the Melbourne Section, held last October, Mr. C. Pullen, M.I.Prod.E., was elected Chairman for the coming year.

Mr. Pullen, who is a founder member of the Melbourne Section, has served in the capacities of Honorary Treasurer and Honorary Secretary, the latter until October, 1952. In addition, he has carried out the duties of Honorary Secretary to the Australian Council and also took a leading part in the inauguration of the Adelaide Section in 1950.

A native of Warwick, England, and educated at Coventry Technical College, Mr. Pullen received his engineering training at The Renold & Coventry Chain Company, The British Thomson-Houston Company, and the Daimler Company. He subsequently became Chief Draughtsman with the Parnall Aircraft Company and later, Production Officer with the Ministry of Aircraft Production. In 1942 he went to Australia on behalf of the Commonwealth Government in connection with a new plant at Fairfield, Victoria, where he was Assistant Manager and Chief Engineer.

In 1945 he was transferred to Fishermen's Bend as Chief Draughtsman of Government Aircraft Factories, where he now holds the position of Acting Chief Production Engineer.

A pleasant ceremony which took place during the Birmingham Section's Dinner Dance last October was the presentation to Mr. Percy Edwards of a silver cigar box, in recognition of his 25 years' continuous service on the Section Committee. This photograph shows General K. C. Appleyard, C.B.E., Past President of the Institution, and Mr. B. G. L. Jackman, Chairman of the Birmingham Section, making the presentation to Mr. Edwards.

These photographs, taken at the Institution's Annual Dinner held on 8th October last, show some of the prominent personalities and Institution members who were present. (1) Mr. A. E. Evans, O.B.E., Technical Adviser to the Association of Teachers in Technical Institutions, Mr. F. Bray, C.B., Under Secretary, Ministry of Education, and Dr. W. Abbott, C.M.G., O.B.E., the Institution's Hon. Educational Adviser; (2) Mr. F. G. Woollard, M.B.E., winner of the Institution's Medal for the Best Paper by a Member, 1952/53, receives his award from the President, Sir Walter Puckey; (3) Mr. D. Whitehead, Lord Austin Prizewinner, 1952/53, is congratulated by the President; (4) The Right Hon. Lord Sempill, A.F.C., Past President, delivers the Address by Sir Ronald Weeks, who was unfortunately prevented from attending by illness; (5) Mr. R. D. G. Ryder, President of the Machine Tool Trades Association; (6) Mr. G. R. Pryor, Chairman of Council, makes his address; (7) Mr. Harry Ward, Secretary of the Industrial Management Research Association, listens with interest to Mr. Harold Burke, Past Chairman of Council, giving some friendly advice to Mr. H. G. Gregory, Vice-Chairman of Council.

Visits to Gibraltar

Lt.Col. J. M. Lyden, O.B.E., Member, Commander of R.E.M.E. Headquarters in Gibraltar, writes to say that he would be happy to welcome members of the Institution passing through Gibraltar at any time of the year, and would be glad to show them round the Rock and in particular the R.E.M.E. Workshops, the Dockyard, and the Airstrip.

Lincoln Section Dinner Dance

The Dinner Dance held by the Lincoln Section on 21st November was a thoroughly successful and enjoyable function, and was attended by a number of distinguished members and guests. Among those present were Mr. Geoffrey de Freitas, M.P., and Past Secretary of State for Air; the President of the Institution, Sir Walter Puckey; the Right Hon. Lord Sempill, A.F.C., a Past President of the Institution; the Right Worshipful the Mayor of Lincoln, Councillor Allan H. Briggs; the Sheriff of Lincoln and his Lady; and Mr. G. R. Pryor, Chairman of Council.

Proposing the toast of "The Institution of Production Engineers", Mr. de Freitas said that Lincoln was known throughout the world by the quality of its engineering production. In the country as a whole, during the past decade, the realisation of the importance of engineering had increased, particularly since the War, as the new and technically minded generation grew up. He felt sure that the Institution of Production Engineers in general, and the Lincoln Section in particular, had a great future ahead of them.

Responding to the toast, the Right Hon. Lord Sempill said that there was a very important place in the world for production engineers. It was a leading position held by invention and application and by the production of the finest equipment and top quality in design, materials and craftsmanship.

Mr. G. R. Pryor, proposing the toast of "The City of Lincoln" referred to the importance of Lincoln not only as an engineering centre, but as a flourishing agricultural centre. It also had the uncommon advantage of being an industrial city and a cathedral city. Living and working in Lincoln, concluded Mr. Pryor, provided more than the average opportunity to live a full and interesting life with the many openings and facilities provided.

Birmingham Section New Chairman

As a result of taking up his recent appointment as General Manager of Minimax, Limited, Middlesex, Mr. B. G. L. Jackman has been forced to resign office as Chairman of the Birmingham Section.

At a recent Section Committee, at which tributes were paid to Mr. Jackman for his sterling work during his period of office, Mr. T. W. Elkington was elected Chairman of the Section for the remainder of the Session. Mr. Elkington is Director of Peter Brasshouse, Limited, Birmingham, a member of the Institution's Research Committee, and past Chairman of the Materials Handling Sub-Committee.

news of members

Mr. L. L. Bott, Member, General Works Manager of Davey Paxman Company Limited, Colchester, has been appointed to the Board. Mr. Bott joined the Sudan Government Railways in 1936 and Ruston and Hornsby Limited in 1944. He became Works Manager of Paxman's Engine Division in 1947, being appointed to his present position in 1951. He is a member of the Eastern Counties Section Committee.

Mr. A. G. Clark, Member, has been appointed Works Manager of the Rolls-Royce Oil Engine Division. He is a Member of Council and also serves on the Institution's Membership Committee.

Mr. Harold Vernon, Member, Director of Thos. W. Ward Limited, has been appointed Chairman and Managing Director.

Mr. L. M. Brooks, Associate Member, has relinquished his position as Chief Ratefixer with British Light Steel Pressings Ltd., and has taken an appointment with the International Labour Office, as Productivity Expert to the Indian Government.

Mr. C. T. Chapman, Associate Member, has given up his position with Lee Guinness Limited of Newtownards, and has been appointed Production Engineer to Hughes Tool Company Ltd., Castlereagh, Belfast.

Mr. J. Gibson, Associate Member, recently relinquished his appointment as Chief Production Development Engineer, with Hoover Limited, in order to go into business on his own account. Mr. Gibson had been with Hoover Limited for 20 years, of which 15 years was spent as Chief Production Engineer at Perivale. He has served on many Technical Committees of the British Standards Institution and the British Plastics Federation, and also on the Standards Committee of the Institution of Production Engineers.

Mr. P. E. Goodwin, Associate Member, is now Treasurer and Chief Engineer of the Defiance Engineering and Microwave Corporation Wakefield, Massachusetts.

Mr. J. Hunter, Associate Member, has now changed his appointment and is Production Engineer at Messrs. Blackburn (Dumbarton) Ltd.

Mr. R. N. Marland, Member, Works Controller of John Wright & Company, Ltd., Birmingham, has been appointed to the Board. Mr. Marland serves on the Materials Handling Sub-Committee of the Institution, and was recently elected to the Conference Organising Committee.

Mr. J. W. K. Murch, Associate Member, is now a Senior Lecturer in Production Engineering at Enfield Technical College, Enfield.

Mr. A. P. Oppenheimer, Associate Member, has now left Hoover (Electric Motors) Ltd., of Cambuslang, and has taken up a position in the Production and Costing Department, Tube Investments (Group Services) Ltd., Birmingham.

Mr. F. T. Pay, Associate Member, is now Production Manager to the Separator Division of Alfa-Laval Company Limited, Cwmbran, Monmouthshire.

Mr. A. J. Plowman, Associate Member, has recently resigned his position with the Associated British Machine Tool Makers Ltd., and is now engaged as Sales Manager at Colchester Lathe Co. Ltd., Colchester.

Mr. W. T. Scarr, Associate Member, has recently taken up an appointment as Senior Engineer in the Auto-Pilot Laboratory of S. Smith & Sons (England) Ltd.

Mr. L. Edward Chadderton, Graduate, is now a Sales Engineer at Wickman Limited, of Coventry.

Mr. F. Bertram, Graduate, has relinquished his appointment with Rolls-Royce Limited, Derby, and has now taken up a position as Assistant Lecturer in the Engineering Department at Beeston College of Further Education, Nottingham.

Mr. F. W. G. Connew, Graduate, has now taken up a post as Instrument Engineer with Procon (Great Britain) Limited, of London.

Mr. M. Gledhill, Graduate, is at present training as an Assistant Field Engineer, with N.V. Nederlandse Aardolie Maatschappij — a member of the Royal Dutch/Shell group of companies.

Mr. P. J. Maltby, Graduate, has taken up an appointment as Technical Assistant in the Research and Development Department of H. M. Hobson Limited, Wolverhampton.

Mr. F. R. Mottershead, Graduate, is now employed as a Designer at Modern Tool Works Limited, Toronto, Canada.

Mr. E. Newman, Graduate, has been awarded a King George VI Memorial Fellowship and is now studying Industrial Administration at the Wharton School of the University of Pennsylvania at Philadelphia, U.S.A., for one year.

Mr. K. D. Park, Graduate, has now taken up the duties of Chief Development Engineer for Exactor Limited, of Edgware.

Mr. G. W. Pitt, Graduate, has relinquished his position as an Inspection Foreman in the Automatics Division of the Lockheed Hydraulic Brake Co. Ltd., and associated Companies, Leamington Spa, and is now studying for an Oxford University Diploma in Economics and Political Science at Ruskin College, Oxford.

Mr. F. Renwick, Graduate, is now employed as an Assistant Development Engineer in a new department set up by Chloride Electrical Storage Company Limited, of Manchester.

Mr. H. L. Robinson, Graduate, is now Factory Manager, at Marley Floor Tile Co. Ltd., at the Harrietsham Kent Factory.

Mr. R. J. Sury, Graduate, has recently been appointed Lecturer in Management Studies in the Department of Production Engineering and Management at Wolverhampton and Staffordshire Technical College.

Mr. D. H. W. Thomas, Graduate, has changed his appointment to Senior Trials Engineer, at Sperry Gyroscope Co. Ltd., Feltham, Middlesex.

Hazleton Memorial Library

REVIEWS & ABSTRACTS

Members are asked to note that the Library will normally be open between 10 a.m. and 5.30 p.m. from Monday to Friday each week. It would be helpful if, in addition to the title, the author's name and the classification number could be quoted when ordering books.

Members are reminded that the Library service is available to all members of the Institution and the Librarian is always willing to assist with enquiries.

REVIEWS

"Machine Tool Operation" by Henry D. Burghardt and Aaron Axelrod. Part I. 4th edition. *London, McGraw-Hill Publishing Co., Ltd.*, 1953. 585 *pages*. £1. 10. 0d.

This is the 4th edition of a work first published in 1919 in the U.S.A. Compared with an earlier edition the work has been modernised and recast, but the friendly approach to the subject matter which characterised the earlier work has been retained. There is a preliminary introduction to the student dealing with the scope of the machine operator's work, his prospects, and brief identifications of the various machines to be found in a machine shop.

The text proper is divided into six sections: safety, measuring tools, bench work, drilling, lathe work, and forging.

Safety, the authors contend, is an attitude; if the operator's attitude towards safety is good he will accept the idea of safe working habits throughout his working life and practice them habitually. The discussion on safety is the finest encountered and its value is enhanced by "action" photographs, although in certain instances the safe methods of performing specific actions may be questioned and regarded as clumsy; this, however, is a purely personal opinion.

The division on measuring tools covers the more common measuring tools including vernier protractors, sine bars and slip gauges. Brief but adequate descriptions are provided but there is no reference to national standards, temperatures or the division into line and end standards. Fig. 3-18 and 3-38 conflict, and together with Fig. 3-22 can be challenged. The use of the universal scribing block base and stem when dealing with a sine bar, slip gauges and a dial indicator as shown in Fig. 3-66 is deplorable. Even with the light type of dial indicator shown, there will be considerable deflection when used at the angle indicated.

Bench work describes the usual bench tools, hammers, chisels, files and scrapers, uses, care and, where appropriate, chapening. The hints and safety rules on chipping are valuable, particularly the hint on developing a rhythm by numbers. No mention is made of rake and clearance relative to the cutting edges of chisels and scrapers, and the division concludes with descriptions of the usual marking out techniques, but no specific problems are included.

The various drilling machine forms are described in adequate detail, but no attempt is made to consider actual mechanisms. The usual drilling tools are considered, together with methods of sharpening, equipment and elemental drilling techniques. The division is concluded with a general review of reamers counterbore and sinkers, and tapping.

The lathe work division broadly follows the plan of that for drilling. Descriptions of the different parts of a lathe are furnished, but without mechanisms. Different tool forms are examined and common elemental operations including chucking, boring, taper turning, and screw cutting are described in full detail. The practice of using a file for finishing turned work can be contested. A student should be trained in the use of the correct form of finishing tool, suitable speeds and feeds. A very noticeable failing of students working in a college workshop is the reluctance to use the graduated dials on the machine slides. It is interesting to speculate on what the older turning foreman would have said had he seen a lathe operator filing a boss of a casting to limits. The section dealing with the action of a lathe tool is of necessity very elementary, but even so, the term "built up edge" should be used instead of "false cutting edge". No attempt is made to identify the basic chip forms.

Forge work includes the usual techniques and tools involved in soldering, brazing, babbitting and hand forging, and concludes with an account of hardening and tempering chisels and screw drivers.

An appendix includes the usual tables.

As indicated, the work is very readable and should be particularly suitable for those pupils in secondary, technical and grammar schools taking metal work, but its price is too high for use in the class-room. Although the work is well written and illustrated, it will not be of great value for those students reading for the elementary examinations leading up to the intermediate City & Guilds' Machine Shop Engineering. Apart from the cost, important machines such as the shaper are omitted in the first part, further such students are required to have a knowledge of the mechanisms of the various machines, and also be able to plan a sequence of operations for simple jobs, and such information is lacking.

In fairness to the authors, they state quite clearly in the preface that the work is in no sense a treatise nor a production manual, but they do concede that the machine operator, as distinct from a semi-skilled machinist, requires a knowledge of the construction of the machine he operates. Consequently, it is claimed that mechanisms of machines are described. "Descriptions of mechanisms of machines" as understood in this country do not appear in this book.

Part II of this work (3rd edition, 1954, 677 pages) has just been received. It contains the following divisions: The Shaper; The Planer; The Milling Machine; The Grinding Machine; Hydraulics; Metal Band Saws; Metallurgy; Cutting Fluids. J.W.B.

"Heat-resisting Steels and Alloys: a Concise Data Book giving the High-temperature Properties of Commercial Steels and Alloys" by C. G. Conway. *London, George Newnes, Ltd.*, 1953. 160 *pages*. £1. 5. 0.

Mr. Conway has gathered together a very comprehensive collection of data dealing with virtually all the materials at present developed for service at high temperatures. The information is presented in a form which should be useful to engineers who wish to obtain an objective assessment of these steels and alloys: the book should be considered as an intelligent grouping of diverse results from many sources, but

it should be recognised that the quality of the data given varies appreciably. The Author rightly mentions in this connection that manufacturers should be consulted when a specific material is of interest.

The division of materials into classes depending upon application is done logically, the separate classification of bolt steels being a useful feature.

The author has omitted two important types of steel from his compilation; the first is the 2¼% Cr. 1% Mo. grade, somewhat akin to the steel designated F in the section on carbon and low alloy steels. This material is being increasingly adopted for steam plant service at metal temperatures up to 1,050°F. The second omission is the 12% chromium steels containing carbide forming elements such as Mo., V and Nb which are now being used for aircraft turbine discs in the temperature range 550°C-600°C.

It is probable that the value of this book would have been enhanced if some attempt had been made to indicate the extent to which the various steels are used and, e.g., in the case of bolt steels, the service temperature range given for each quality considered.

The following points of detail should be mentioned: Grades A, C and E in the carbon and low alloy steel section should preferably not be stress relieved above 650°C. if it is desired to retain a high level of creep resistance. In the section on bolt steels (page 49) grade BA should not be used beyond 900°F., except, perhaps, for short service life. It is doubtful if grade BF would be suitable for bolting at temperatures as high as 650°C., at which temperature austenitic materials would be more suitable. In the section on austenitic steels, it seems rather unnecessary to give three separate classifications (CD, CH and CJ) for the Niobium stabilised 18/8 type steel. The final section dealing with special heat-resisting steels could perhaps be further sub-divided into cobalt-base alloys as well as iron and nickel-base alloys.

It should be pointed out to users of this data compilation that, particularly with the more highly alloyed materials, the effect of heat treatment upon the creep resistance can be as great within one quality as between two differing compositions.

The above comments do not, however, detract from the Author's achievement in presenting a very clear picture of material properties and usage based on very variable sources of information. The illustrations included are very helpful to the general understanding of the subject, as are the several explanatory comments such as the note on stress-relaxation. M.G.G.

"Kempe's Engineers' Year-Book for 1954" 59th edition. Edited by C. E. Prockter under the direction of B. W. Pendred. *London, Morgan Brothers, Ltd.,* 1954. 2 *volumes, illustrations, diagrams.* £3. 15. 0.

This well-known reference book on general engineering is stated to have been revised completely and includes several new chapters, including some on atomic power, explosives, industrial safety, etc.

Perhaps the main value of an engineering encyclopaedia of the type under review is that it gives background information on aspects of engineering that may be unfamiliar to the narrow specialist. By reading the appropriate section, for instance, a production engineer can obtain, in very concise form, a lot of information about factory safety. In fact, the section on factory safety packs a tremendous amount of information and is authoritative in that it was compiled under the supervision of the Royal Society for the Prevention of Accidents.

The value of the book to the production engineer can be gauged from the fact that of the 72 specialist Authors who have contributed material, there is only one member of the Institution of Production Engineers listed. Some of the workshop practice techniques described would be open to question by expert readers. For instance, the information about lathe tool shapes would appear to be somewhat outdated and the heat treatment of high speed steel does not appear to have been dealt with adequately. These two volumes, however, make very pleasant browsing for those who want to know what goes on in other branches of engineering. C.T.B.

OTHER ADDITIONS

310 STATISTICS

Organisation for European Economic Co-operation, Paris. **"Basic Statistics of Industrial Production, 1913-1952."** *Paris, O.E.E.C.,* 1953. 100 *pages.* 10/-. (O.E.E.C. Statistical Bulletin.)

Central Statistical Office. **"Annual Abstract of Statistics, No. 90, 1953.** *London, H.M.S.O.,* 1953. 317 *pages. Tables.* £1. 1s. 0d.

U.S.A.—Bureau of the Census. **"Statistical Abstract of the United States."** 74th Edition. . . . 1953. *Washington, Gov. Printing Office,* 1953.

331.1 PERSONNEL MANAGEMENT

Glover, John Desmond, *and* Hower, Ralph M. **"The Administrator: Cases on Human Relations in Business."** Rev. Edition. *Homewood, Ill., Irwin,* 1953. 723 *pages.* [A collection of cases which have been used in teaching the subject Adminitsrative Practices at the Harvard Graduate School of Business Administration.]

Rice, A. K. **"The Use of Unrecognized Cultural Mechanisms in an Expanding Machine-shop; with a contributiin to the theory of leadership.,'** (The Glacier project—III.) *London, Tavistock Inst. of Human Relations; Ann Arbor, Mich., Research Centre for Group Dynamics,* 1951. 143-160 *pages.* (Reprinted from *Human Relations,* Vol. 4, No. 2, May, 1951.)

331.11 SELECTING AND ENGAGING STAFF

Ministry of Labour and National Service. **"Selecting the Man for the Job."** *London, the Ministry, and the Central Office of Information,* 1953. 29 *pages. Illustrated.*

331.126 LABOUR TURNOVER

Rice, A. K. **"An Approach to Problems of Labour Turnover: a Case Study [in the Glacier Metal Co. Ltd.], 1953."** 19-47 *pages. (British Management Review,* Vol. 11, No. 2, Jan., 1953.)

Terry, Neville V. **"The Foreman and Labour Turnover."** *Birmingham, Institute of Industrial Supervisors,* [195-]. 16 *pages.* 2/6.

331.14 SUGGESTION SCHEMES

Maytag Company, Newton, Iowa. **"Your Rewards through Work Simplification and Employees' Idea Plan."** *Newton, the Company,* 1949. 38 *pages. Illustrated. Charts.*

331.4 WOMEN WORKERS

Harris, E. M. **"Married Women in Industry."** *London, Institute of Personnel Management,* 1954. 30 *pages.* 4/-. (Occasional Papers, No. 4.)

331.816 ABSENTEEISM

Acton Society Trust, London. **"Size and Morale: a preliminary study of attendance at work in large and small units."** *London, the Trust,* 1953. 44 *pages.* 3/6.

334 CO-OPERATION

"Co-operative Information." 30th year, Nos. 5-6, 1953. *Geneva, International Labour Office.* 30 *pages typescript.* [A review of the I.L.O.'s work in the field of co-operation.]

338.9 PRODUCTIVITY

Hutton, Graham. **"We, Too, Can Prosper . . . speech . . . Manchester, 1954."** *London, British Producitvity Council,* 1954. 16 *pages.* 1/-. [A summary of the argument in his book, "We, Too, Can Prosper."]

Organisation for European Economic Co-operation, Paris. **"European Productivity Agency—Productivity and Applied Research Committee."** Interim director of productivity centres in member countries. *Paris,* 1954. 72 *pages. Duplicated.*

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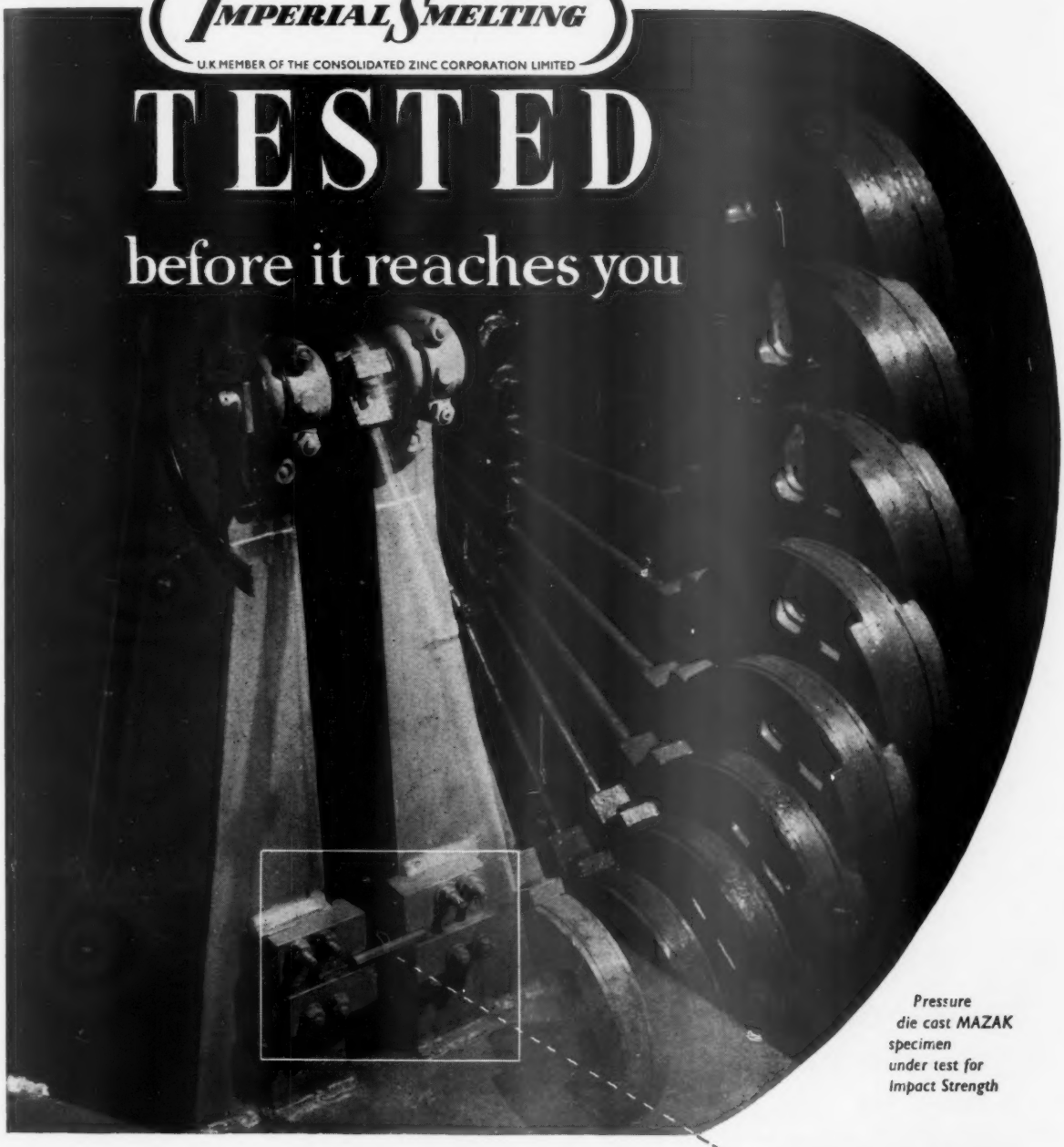

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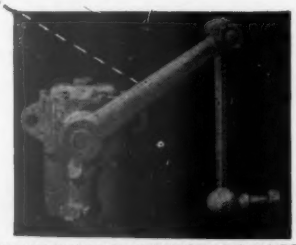

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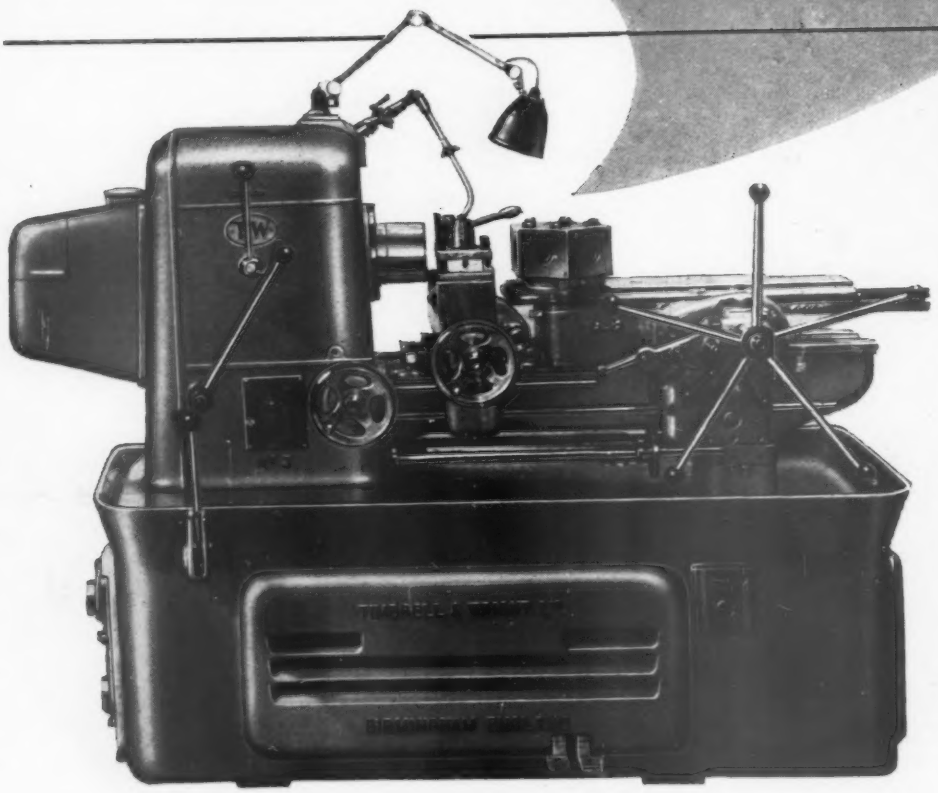

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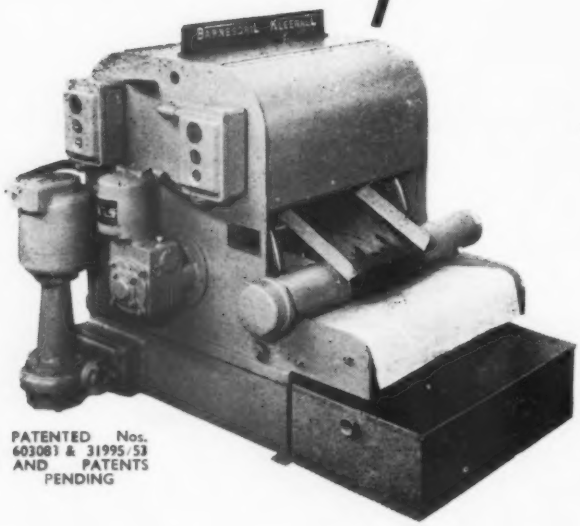

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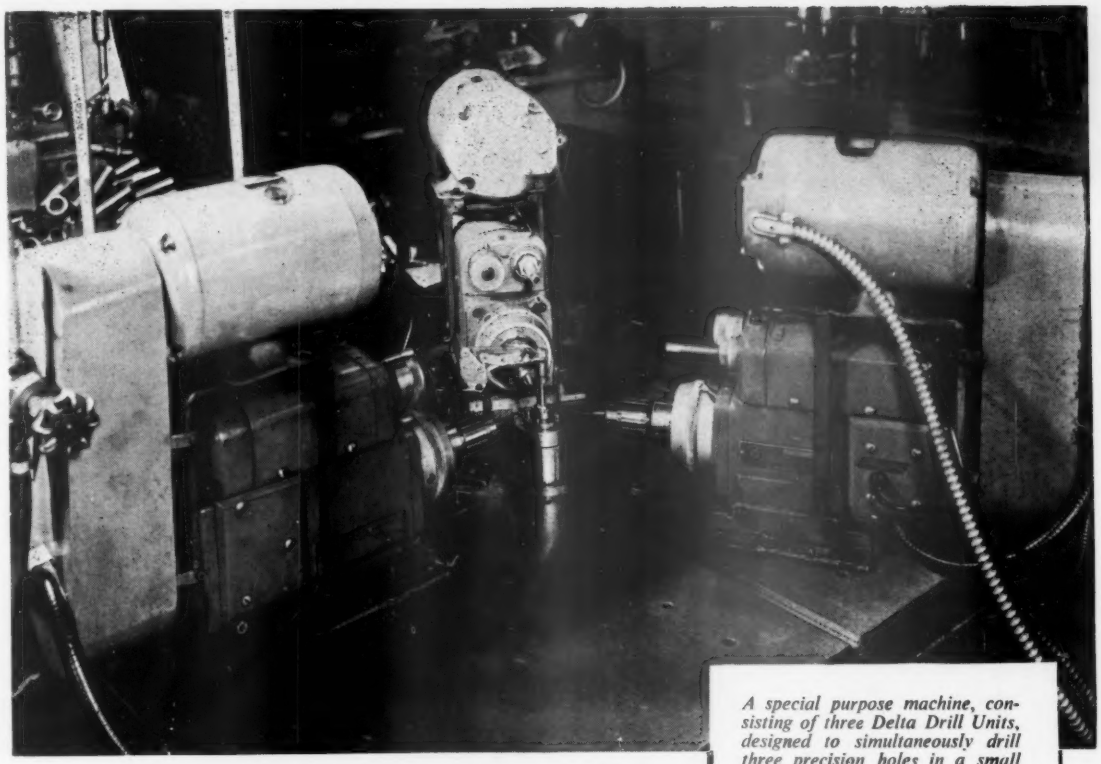

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The operation cuts parts cost 43%.

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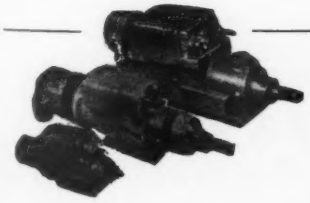

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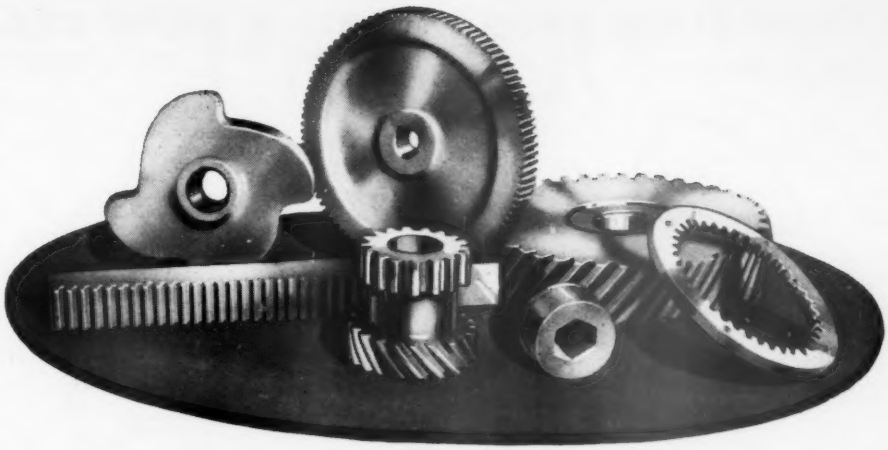
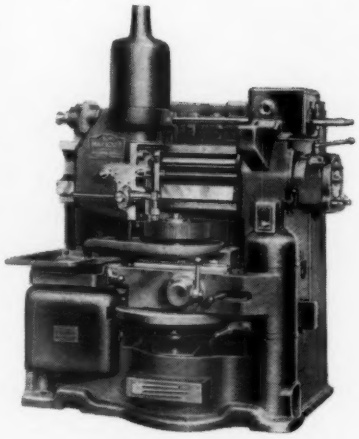


For highest production—



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16-speed power-operated Preoptive Headstock saves all idle time due to speed changing.

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ADMITS BARS UP TO 2"

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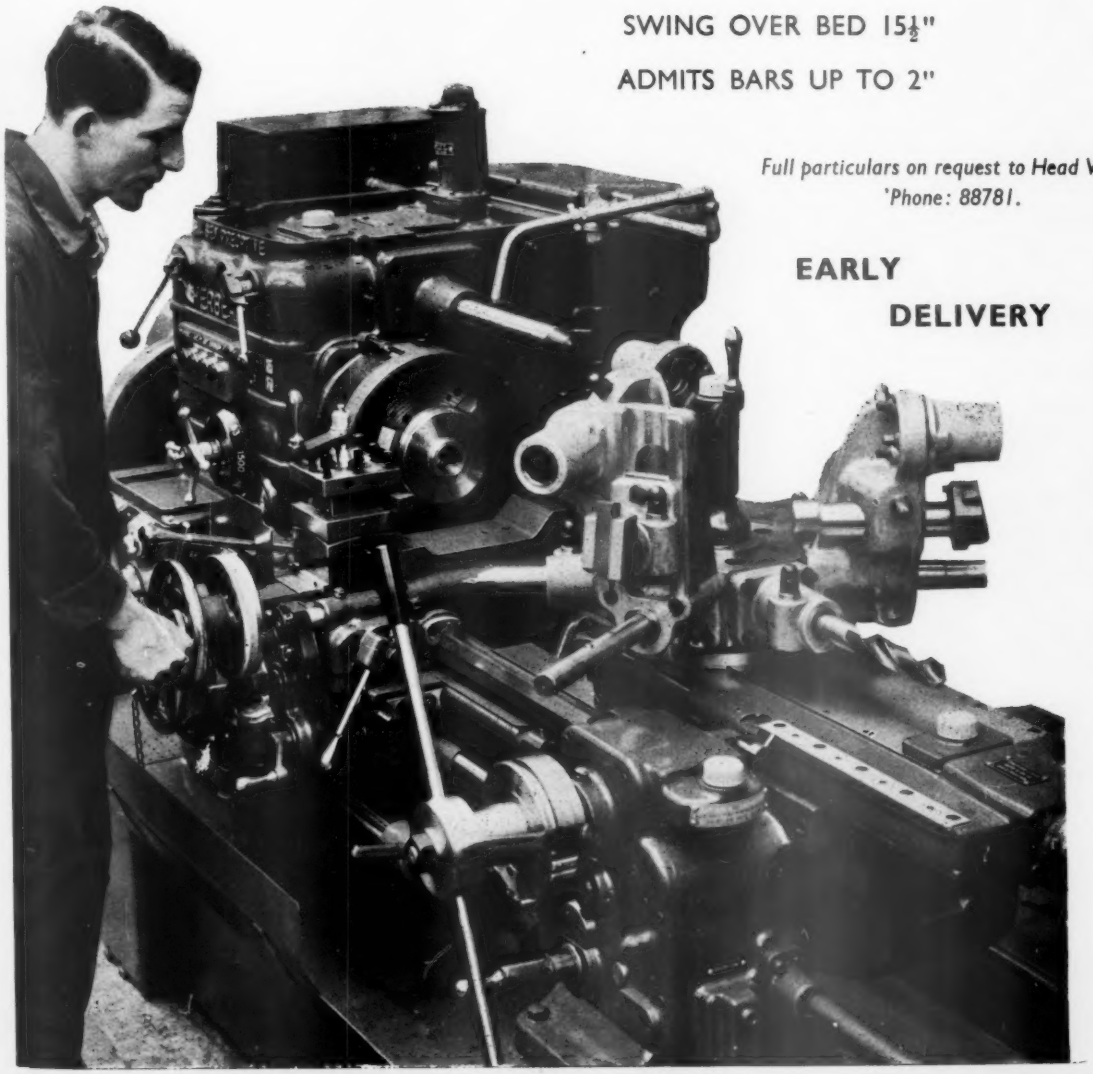

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By their ability to maintain low limits and fast production rates CHURCHILL Precision Grinders make an important contribution to the outstanding achievements of the British Aircraft Industry.

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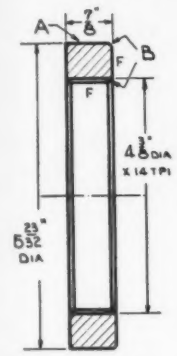
40 Ton Tensile Steel Forging, En.8. Tungsten Carbide Cutting Tools.

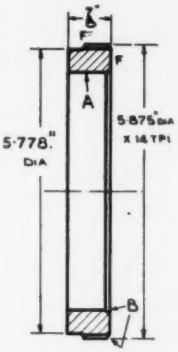


Part No. 1
Floor to Floor Time:
2½ minutes

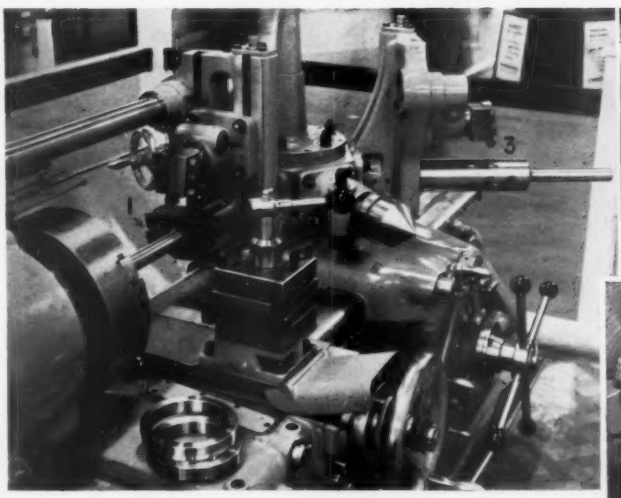
DESCRIPTION OF OPERATION	Tool Position		Spindle Speed R.P.M.	Surface Speed Ft. per Min.	Feed Cuts per inch
	Hex. Turret	Cross-slide			
Part No. 1					
Chuck on A	—	—	—	—	—
Face End Size Bore and Chamfer B	3	S.T.1	416	620	133
Screw Cut 4⅜" dia. × 14 T.P.I. (5 cuts)	—	Rear	416	475	14
Remove	—	—	—	—	—
Part No. 2					
Chuck Internally at A	—	—	—	—	—
Finish Turn 5⅞" dia., Chamfer B and Face End	1	S.T.1	416	640	133
Turn 5·778" dia.	—	S.T.3	416	640	133
Screw Cut 5⅞" dia. × 14 T.P.I. (5 cuts)	—	S.T.4	416	640	14
Remove	—	—	—	—	—

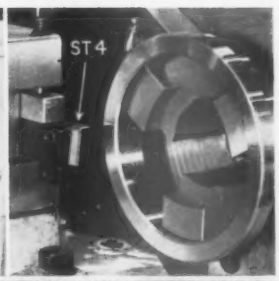
LOCKING NUT **SCREWED RING**

40 Ton Tensile Steel Forging, En.8. Tungsten Carbide Cutting Tools.



Part No. 2
Floor to Floor Time:
2½ minutes





OUR COMPLETE RANGE INCLUDES CAPSTAN AND TURRET LATHES WITH CAPACITIES UP TO 35 in. SWING OVER BED AND 8½ in. DIA. HOLE THROUGH SPINDLE.

Capacity:
2⅛ in. dia. hole through spindle.
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Spindle:
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Powerful metal-to-metal cone clutches transmit power through ground gears.

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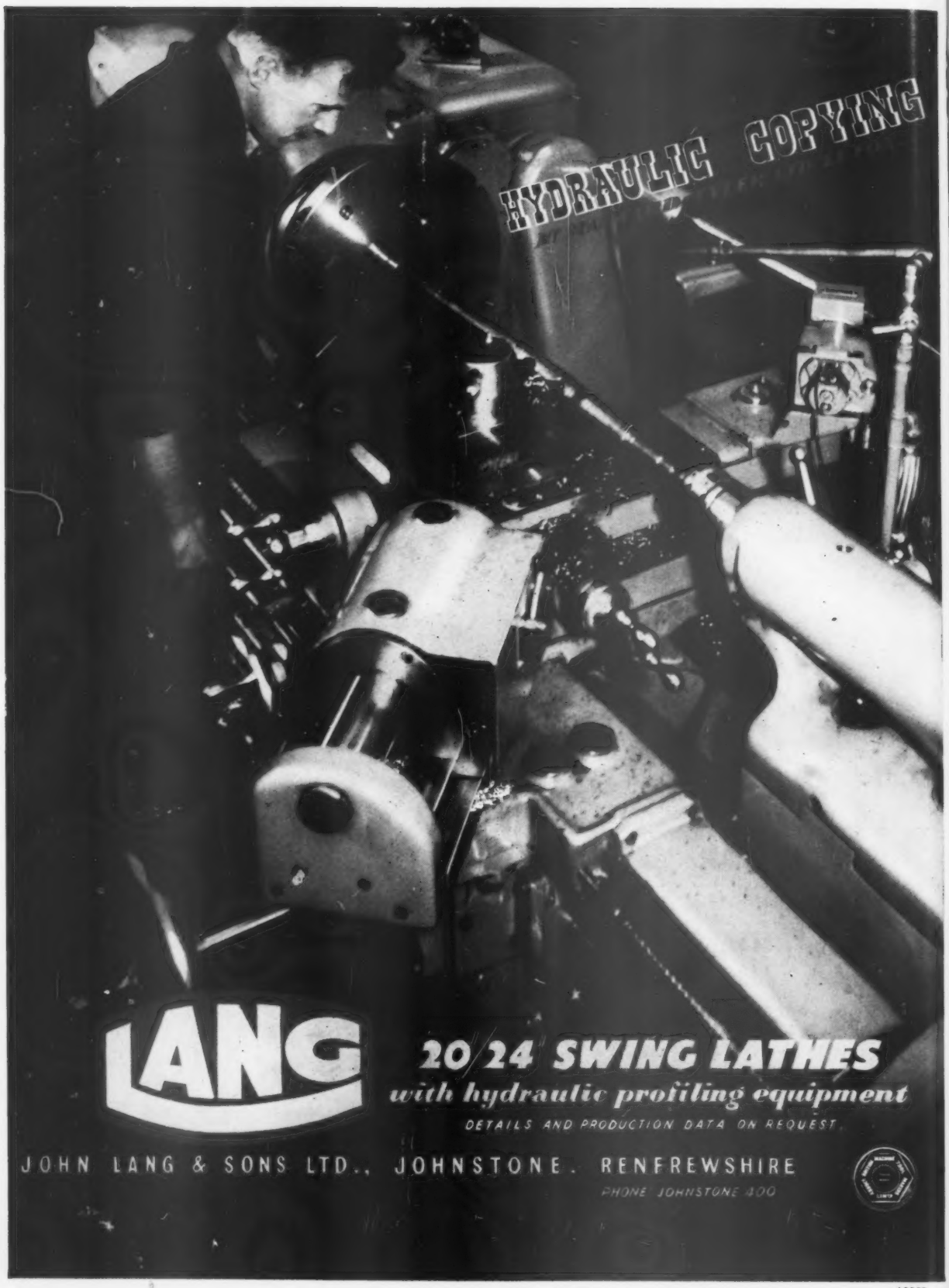
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20/24 SWING LATHES
with hydraulic profiling equipment
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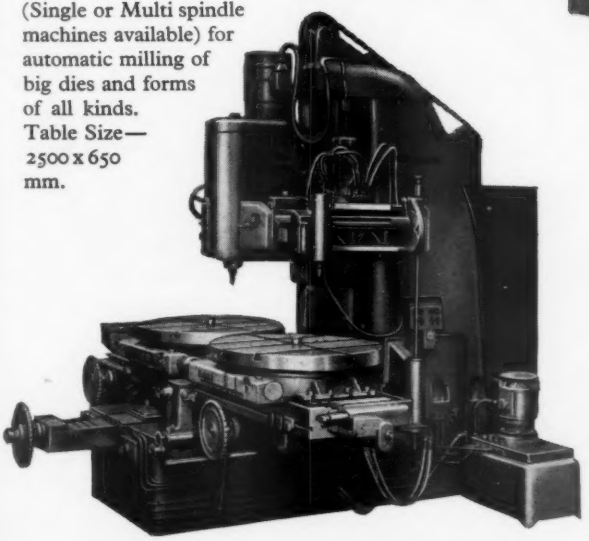

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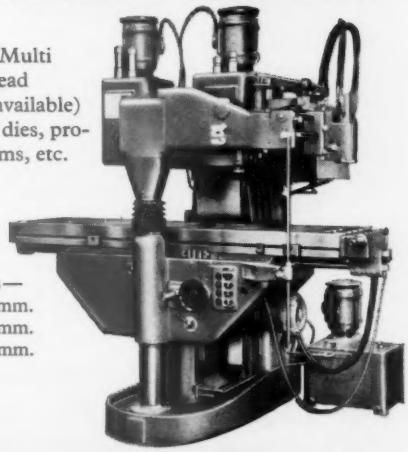
(Single or Multi Spindle Head machines available) Forms for dies, profiles for cams, etc.



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1500 x 400 mm.
2000 x 600 mm.
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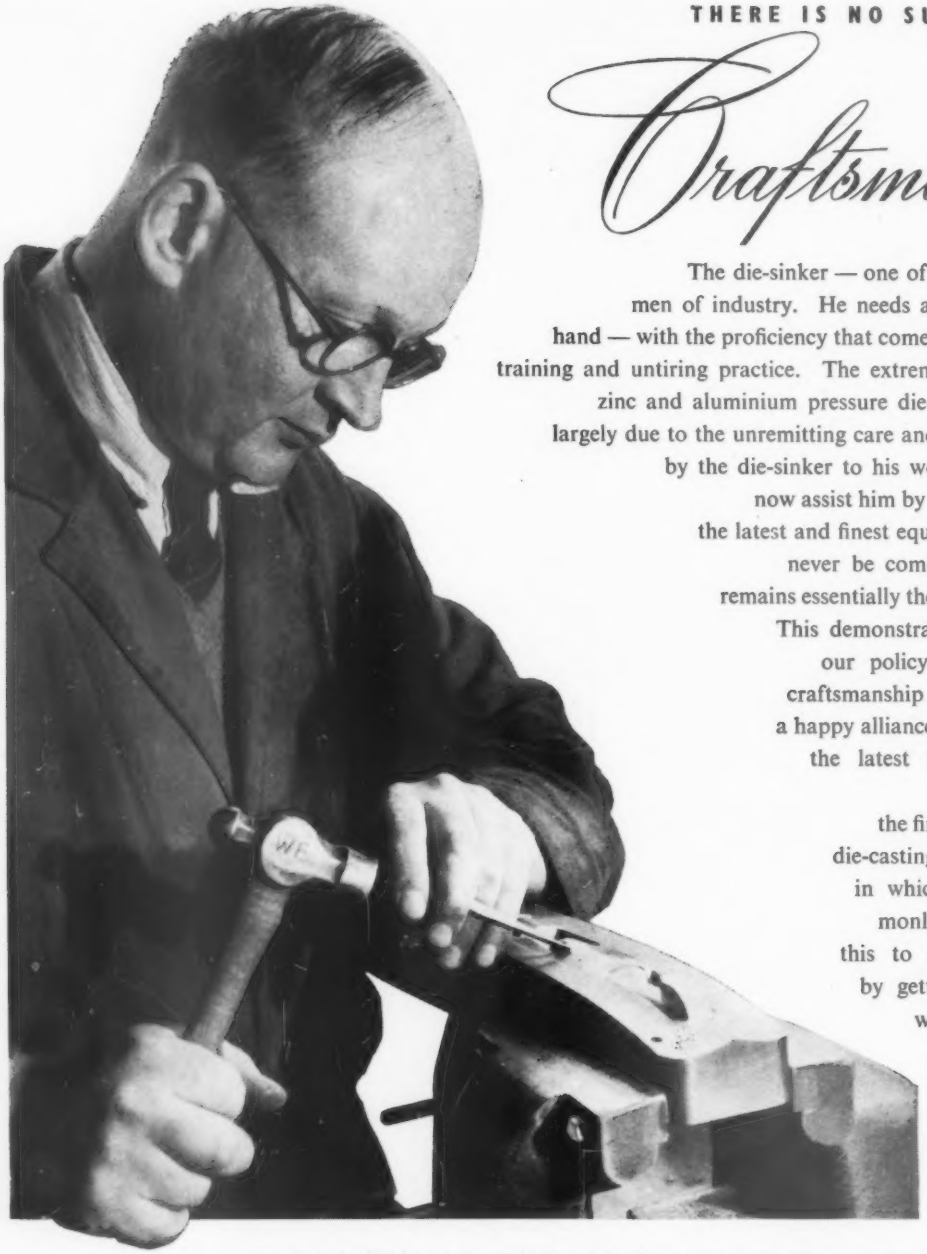

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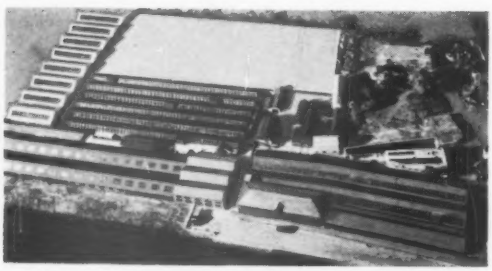

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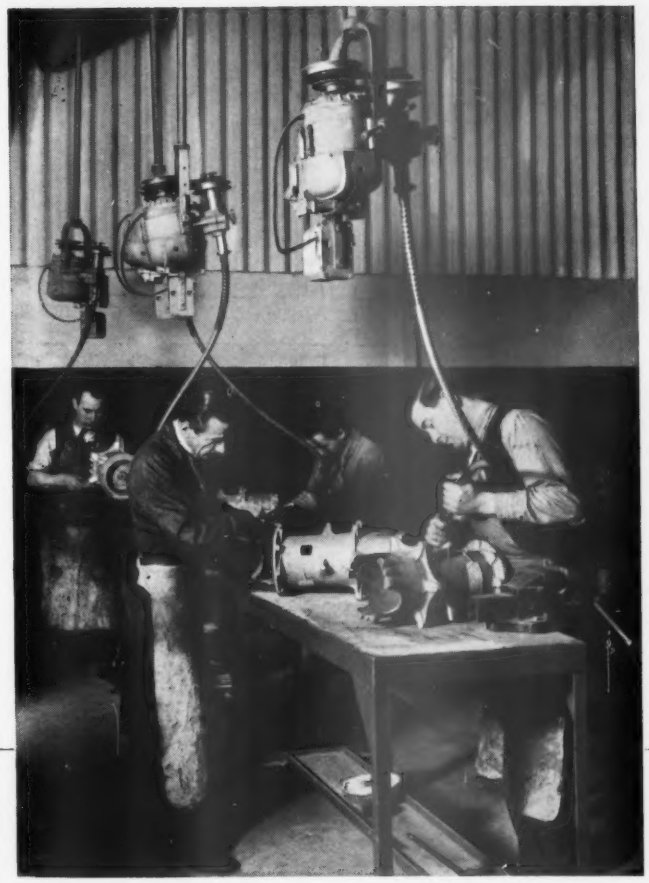
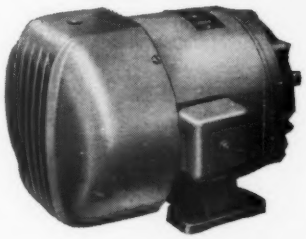
Fractional horsepower motor applications





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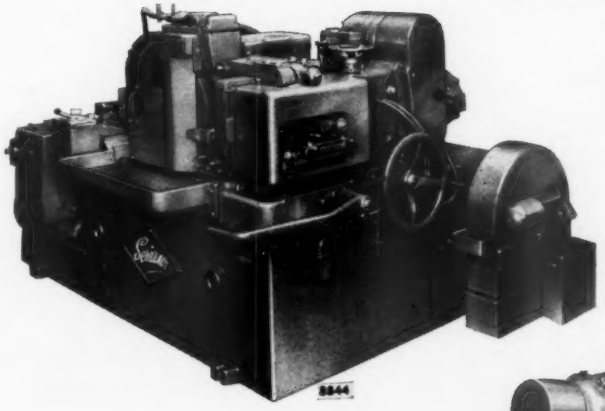

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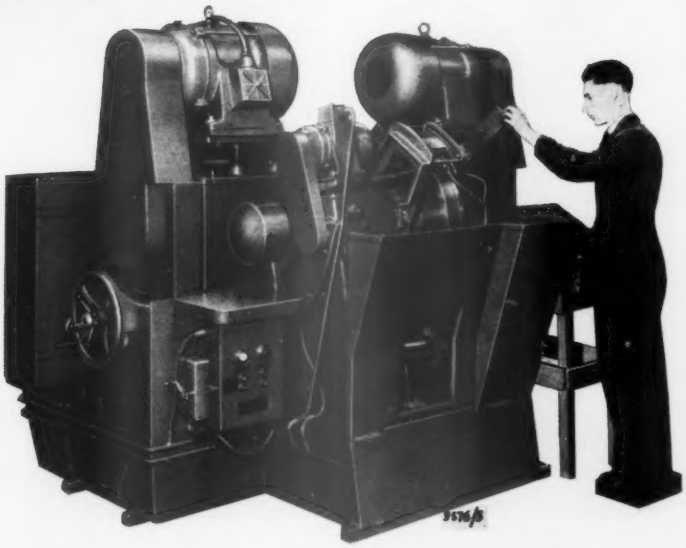

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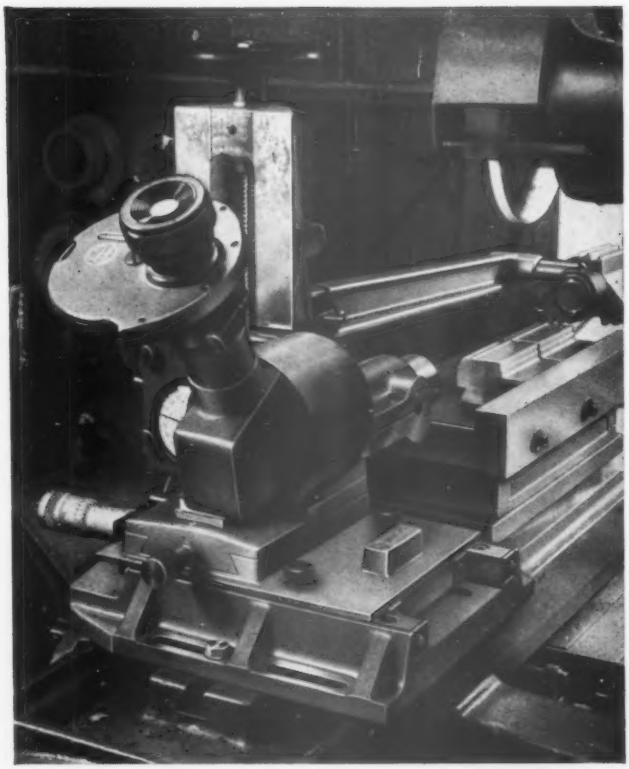

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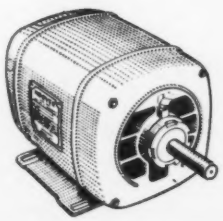

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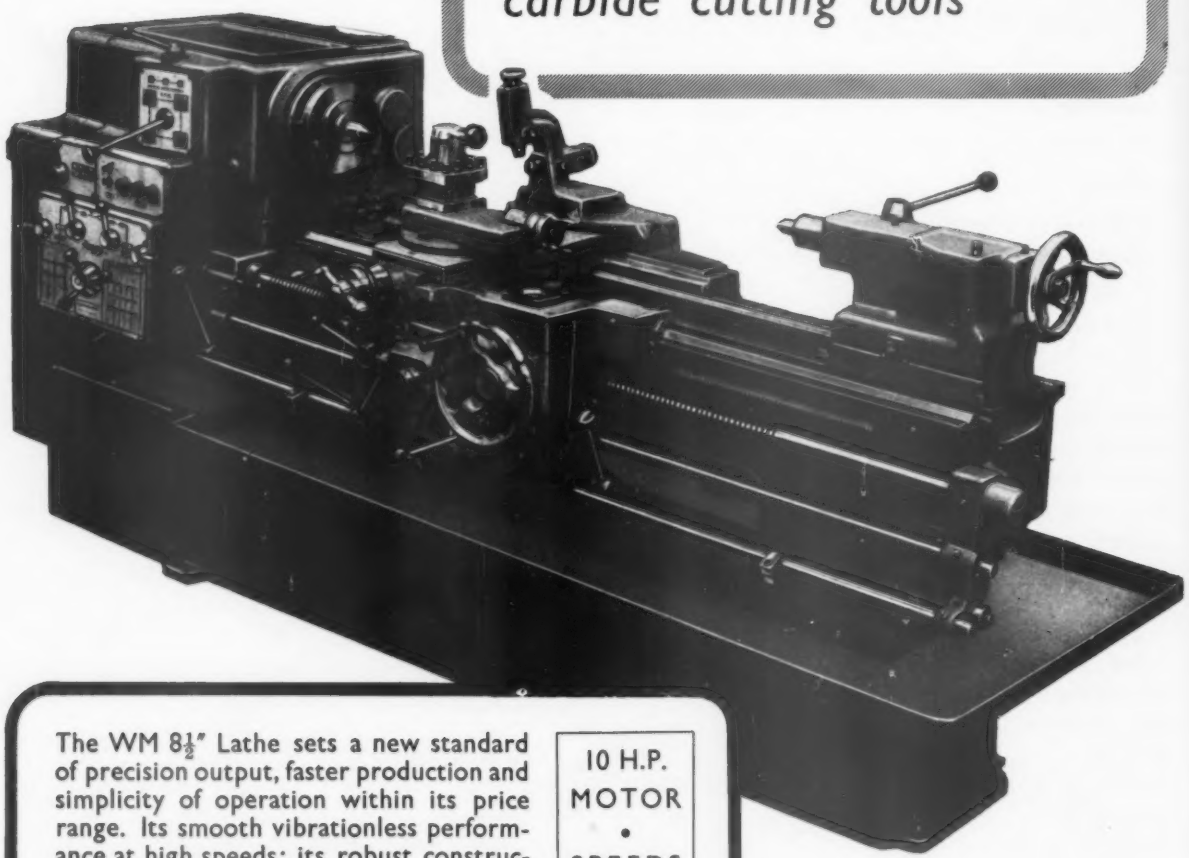

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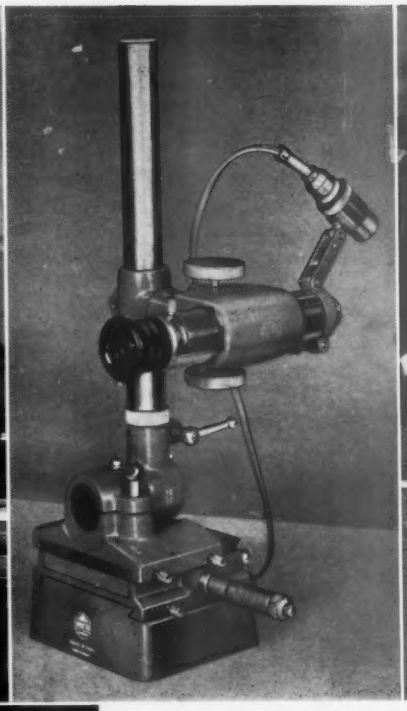

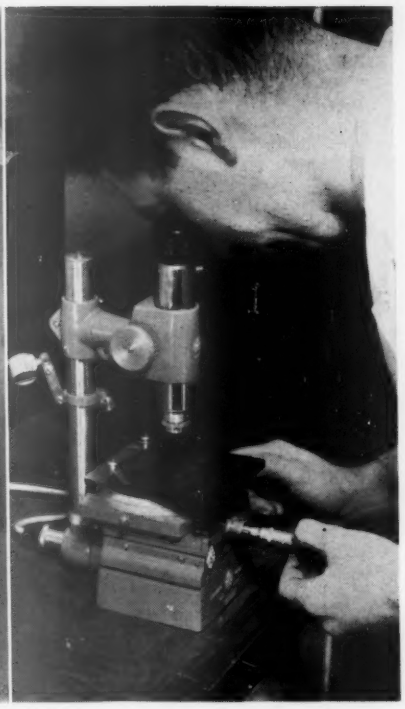

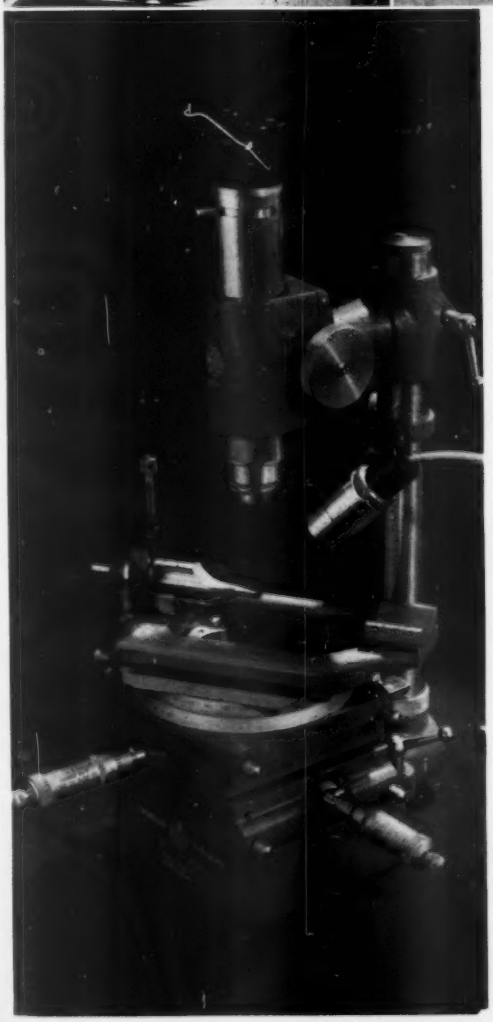

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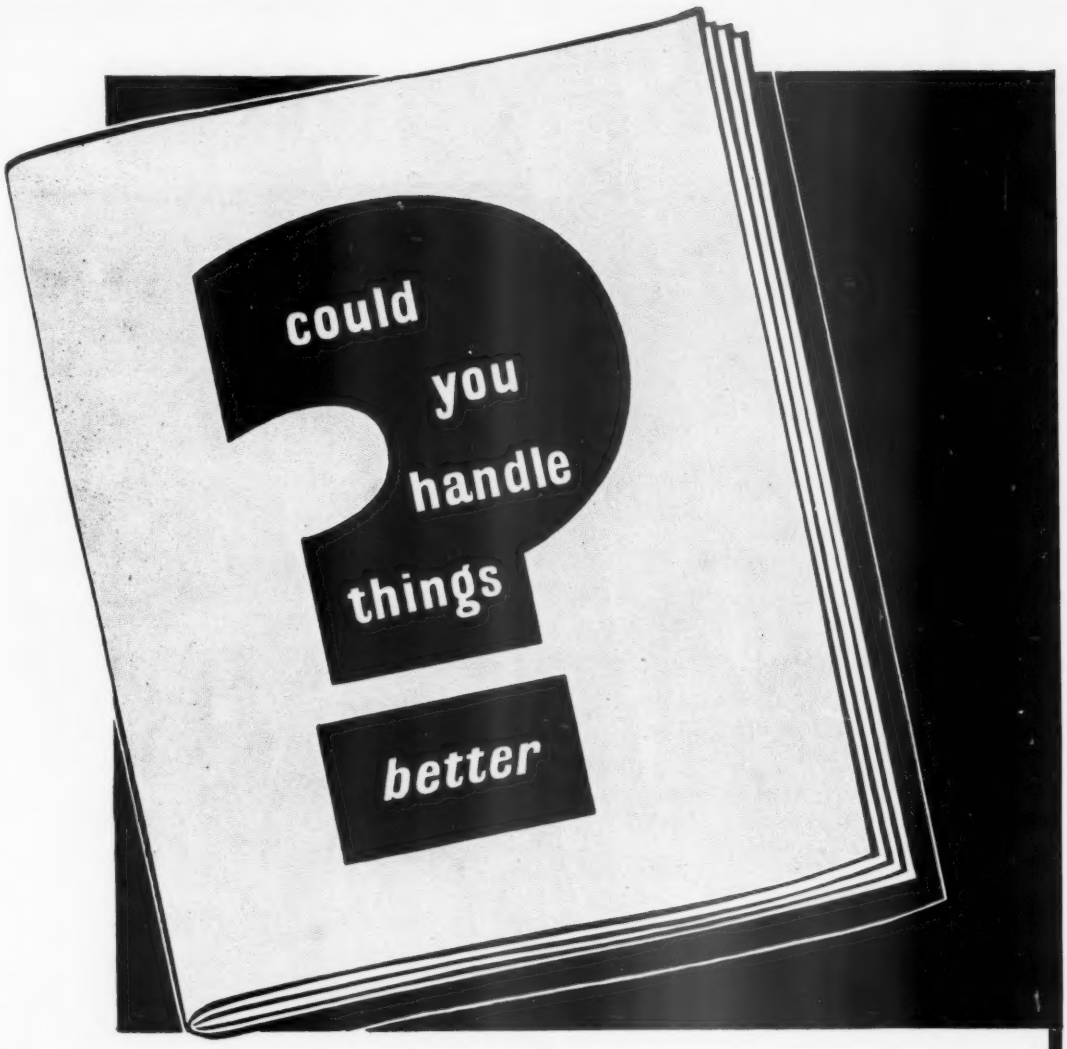

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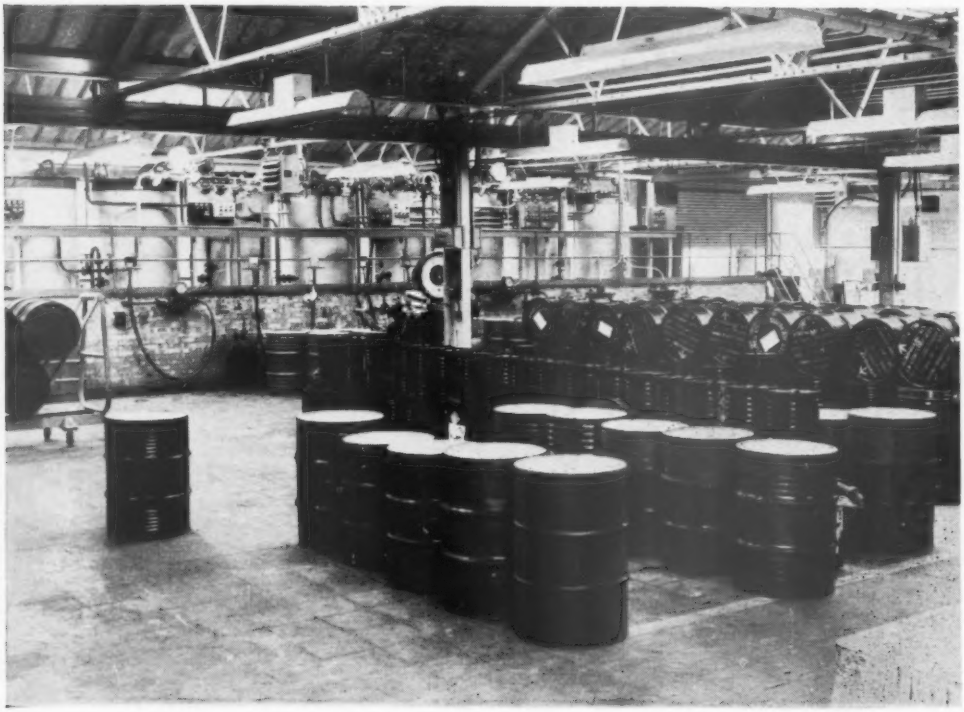

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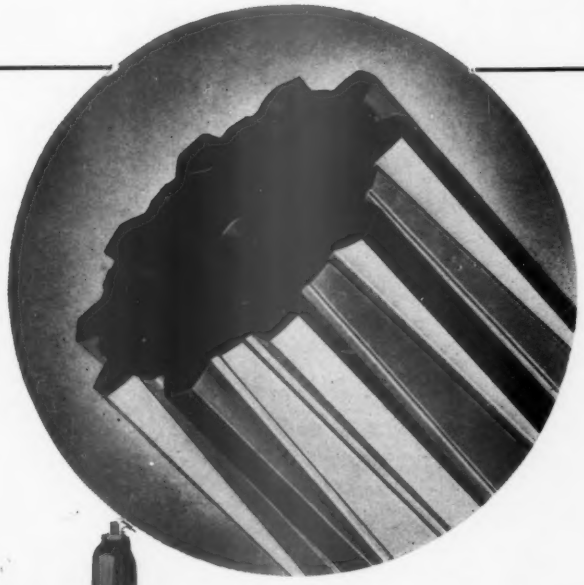

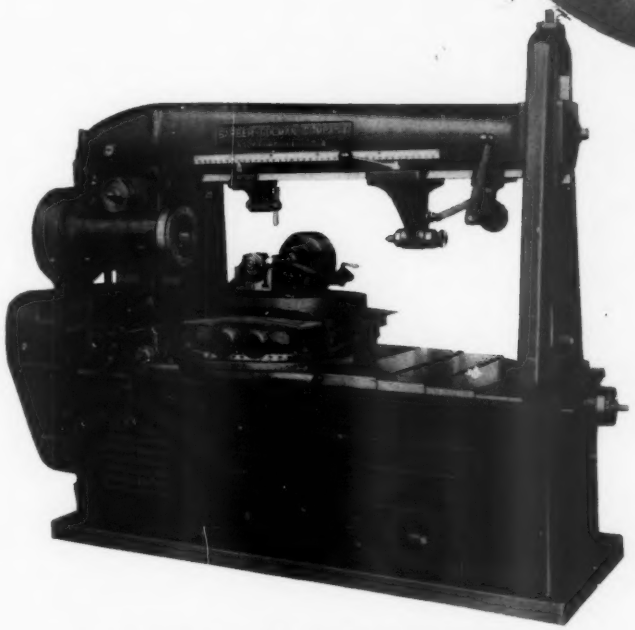

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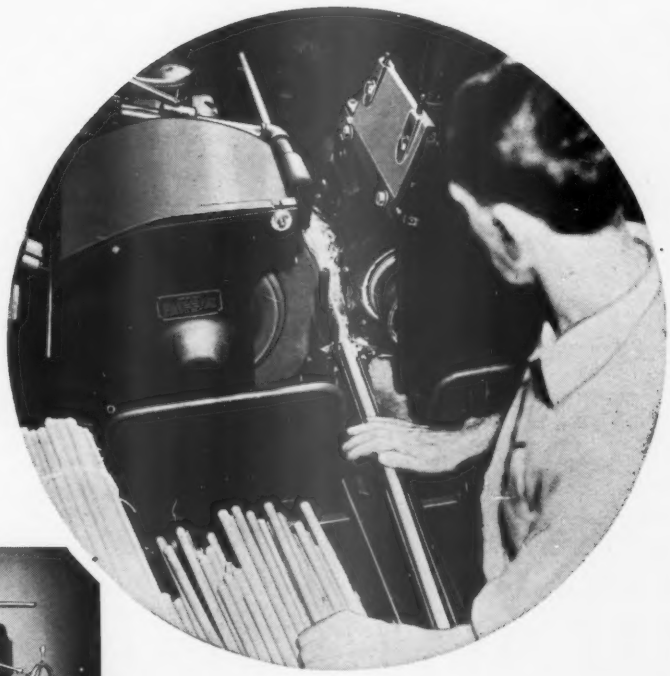

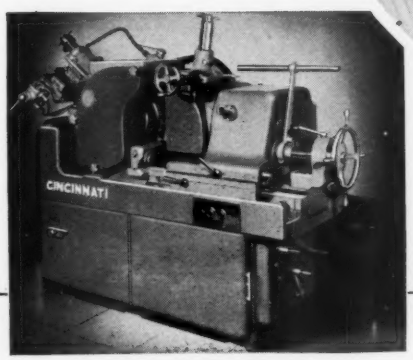

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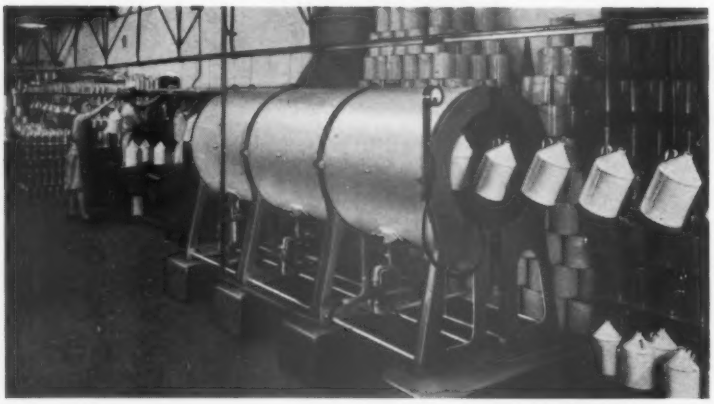

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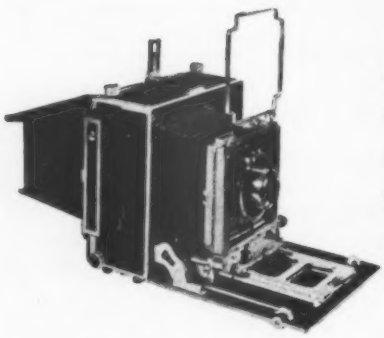

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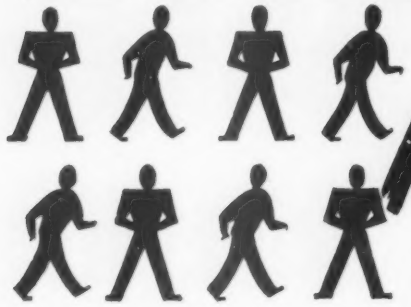

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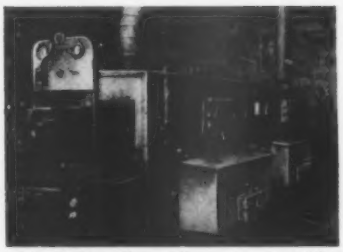
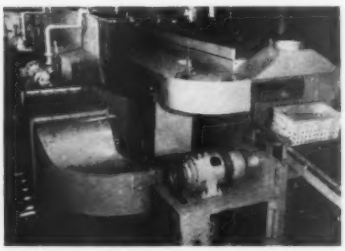
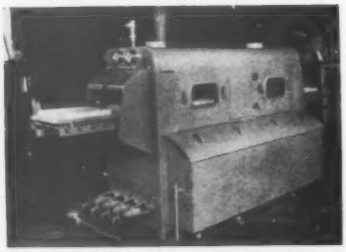


This illustration shows a machine cleaning crank cases in the production line. It is equally capable of cleaning small parts in baskets.



A power driven conveyor system is employed with this cleaning machine for ball bearings.



Trays carrying the work are pushed through on a roller conveyor by hand in this cleaning installation.

Whilst offering a very wide variety of standard cleaning equipment, it is BRATBY policy, wherever possible to design the machine to meet the particular cleaning problem. Careful study of each individual problem ensures maximum efficiency and economy of the plant in operation. The illustrations show but a few of the specific types of Cleaning Machines designed by BRATBY for individual needs.

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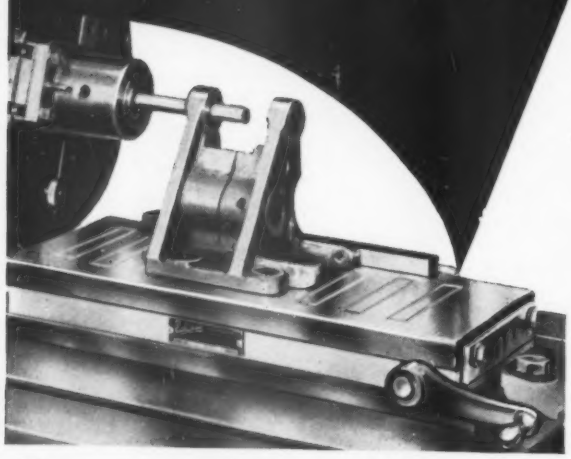

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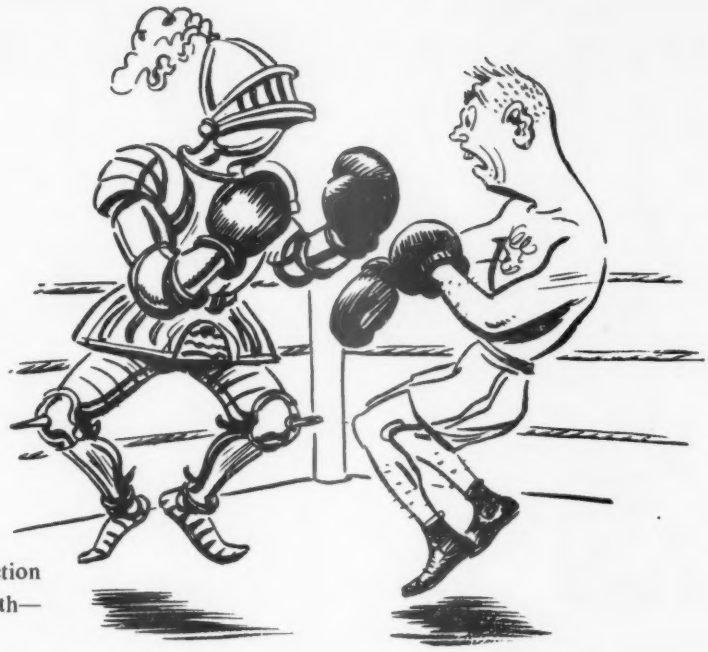
When your punches count—



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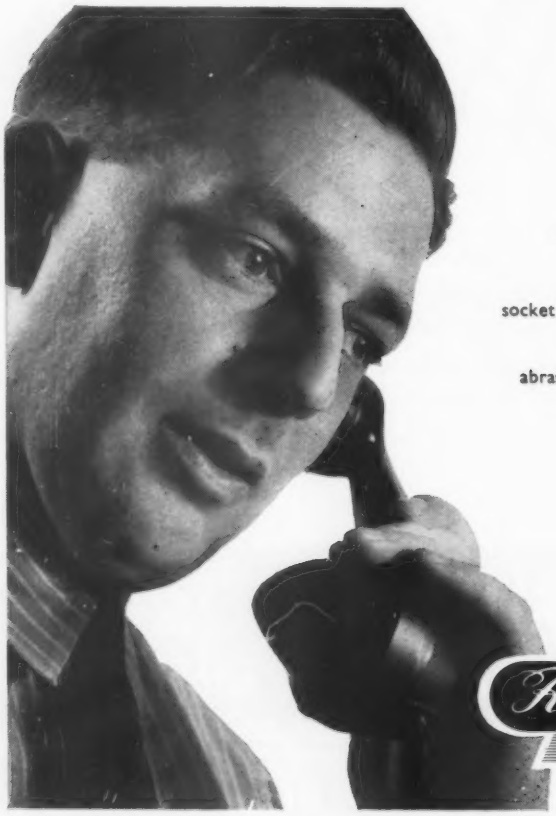

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said the Works Manager

He didn't look good at all. All the marks of a long spell of strain. "For months I've been doing the impossible", he bawled, as we threaded our way through the factory. "And because I did it last time they think I can do it again. Not a square inch of floor space, and now *I'm told to find room for a test bench . . ." We stopped him before he exploded. Gently we told him his worries were at an end. We were from Yale. We'd been called in by the management to plan a new scheme for materials handling.*

"Materials handling? . . . that's what I told them six months ago! Clear at least three aisles and we could stack to the end bay northlight . . . Well, well.

Here, let me show you the annexe . . ."

He moved like a different man. He had ideas. We had ideas. Together we plotted a scheme that gave him just what he wanted. And, not surprisingly, we pleased the management too — when they saw the turn their costs would take.

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AMONG the wide range of Yale handling equipment the "Worksaver" series of trucks is of special interest to factories where restricted space or low-load floors have previously made mechanical handling impractical. Its small size, light weight and extreme ruggedness give big-truck advantages with small-truck economy and convenience.

It will lift, move and stack raw materials or finished products. It saves time, space and manpower. You can ride it or walk it. And it will start cutting costs from the minute you put it to work.

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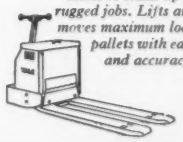
Built to stand up to rugged jobs. Lifts and moves maximum load pallets with ease and accuracy.



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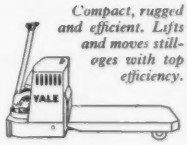

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A powerful and manœuvrable tractor unit to pull trailers or trailer trains with up to 700 lbs. drawbar pull.

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- *Light weight with great strength and power permit heavy duty work on low-load floors.*
- *Dead man control cuts power and applies brakes automatically in emergency.*
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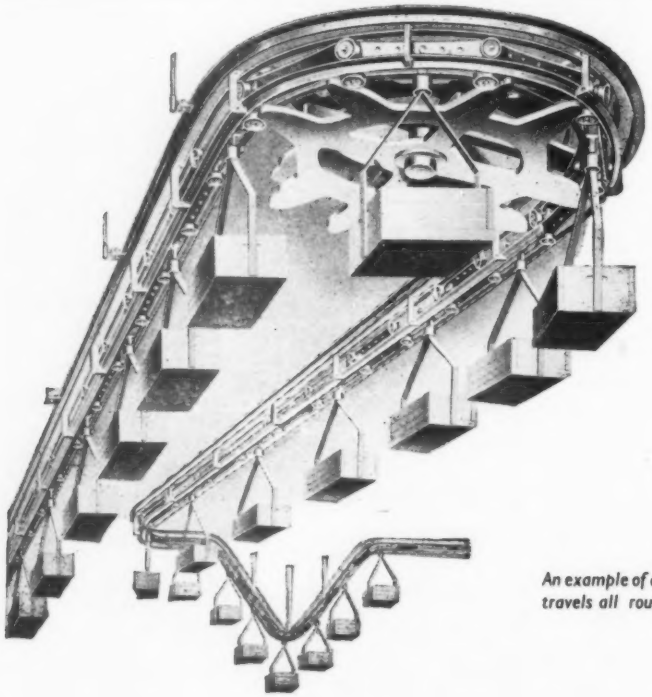

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It is flexible in both horizontal and vertical planes and has full load capacity throughout the rise and fall

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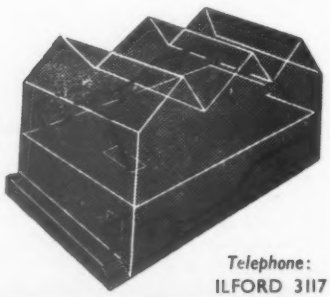

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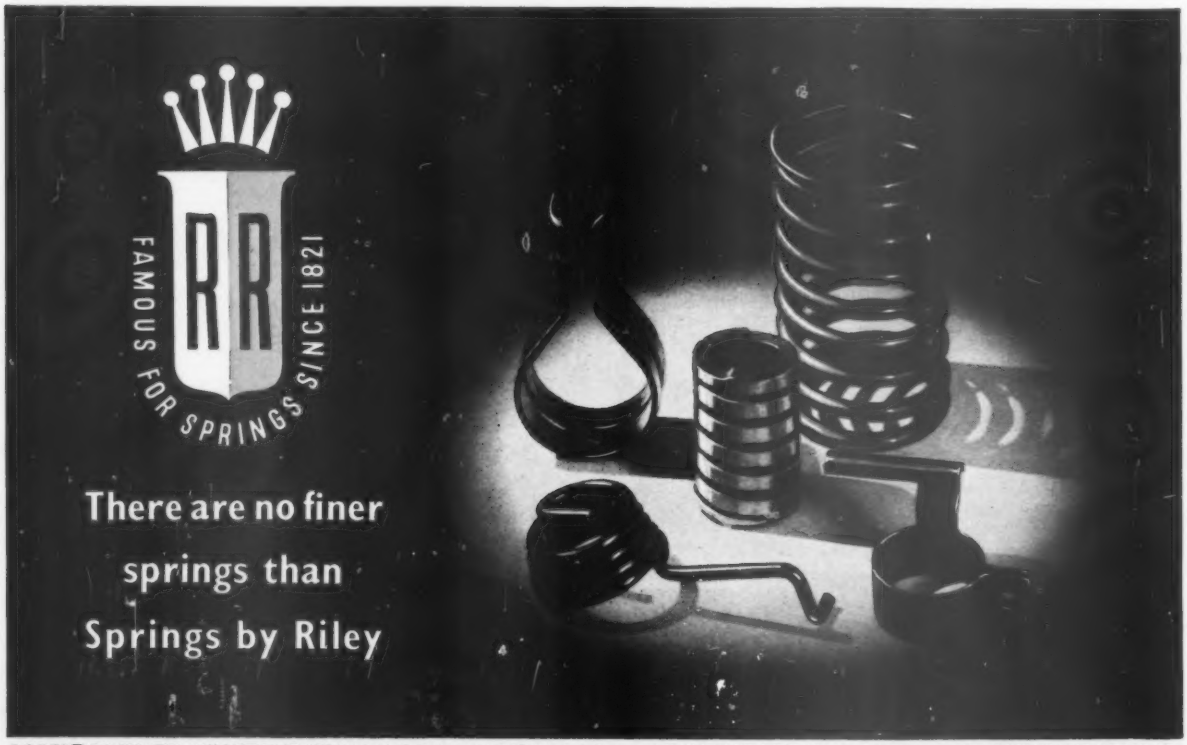

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OUR REF. K/DL 29th January, 1954

YOUR REF. RS/MD

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Yours faithfully,
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We also manufacture:
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with the same high degree of precision

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The Wadkin range of metal machines already available includes:

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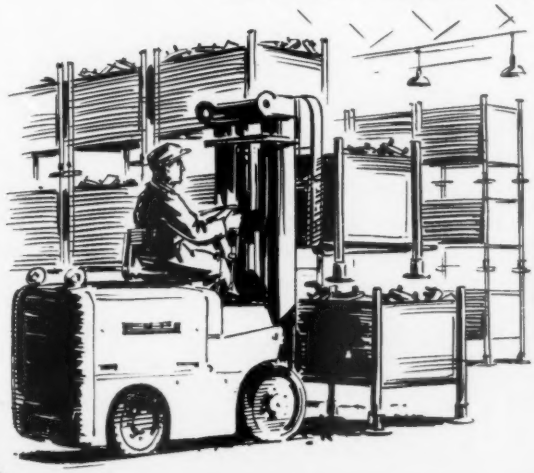

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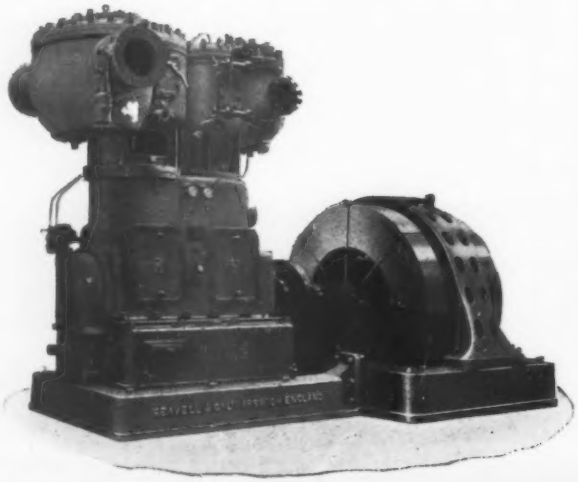

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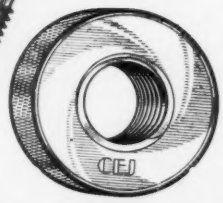

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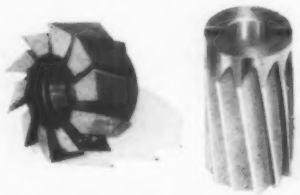

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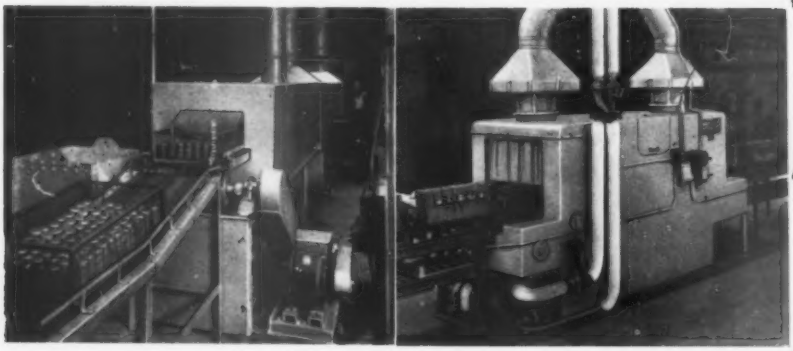

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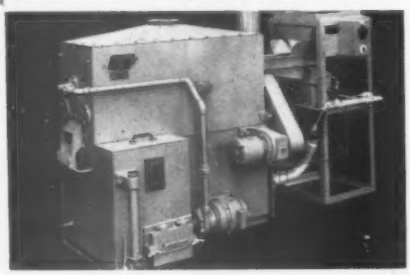

THE MACHINIST

A BRITISH McGRAW-HILL PUBLICATION

McGRAW-HILL HOUSE, 95 FARRINGDON STREET, LONDON, E.C.4.

CENTRAL 0911

An Important Announcement

Three years ago THE MACHINIST's Editor wrote : ***"Automaticity is no pipe dream. The automatic factory is the logical conclusion.***

Today, Britain's Cabinet Ministers freely acknowledge the immense possibilities of automatic production. Mr. Geoffrey Lloyd, the Minister of Fuel and Power, said in the House: "*Britain is already on the threshold of intensive mechanization.*" The Chancellor (Mr. Butler) declared: "*It may be possible to double the standard of living in 20 to 25 years.*" Even the word "AUTOMATION" is gaining acceptance in this country as the simplest description for the full automatic handling of parts from one operation to another.

Now, we learn that the INSTITUTION OF PRODUCTION ENGINEERS has boldly, and with commendable foresight, decided that . . . . THE AUTOMATIC FACTORY is the subject for their National Conference at Margate in June next year.

THE MACHINIST, with its unique McGraw-Hill organisation for presenting up-to-the-minute practical information from all sources, has kept itself to the fore in reporting these developments on both sides of the Atlantic. Regular readers will know that we have already published several feature articles on this vital subject, and in the immediate future will be spotlighting automatic operations in the journal. You should not miss these issues:—

Vol. 98 No. 48 Nov. 26	What is this Automation?
Vol. 98 No. 49 Dec. 3	How can you Automate?
Vol. 98 No. 50 Dec. 10	Numerical Control of Machine Tools—1
Vol. 98 No. 51 Dec. 17	„ „ „ „ „ —2
Vol. 99 No. Jan. issues:	Special Reports—"American Motor Industries Use Automation"

If you are not already a subscriber, or do not get a copy regularly through your newsagent, you are advised to complete the coupon to ensure reservation of your copies for this significant series. An annual subscription to THE MACHINIST costs only 45/-, and if we receive instructions promptly, your subscription can commence with the issue of November 26. And of course, it will cover the period through next year's conference which THE MACHINIST will report fully for those unable to attend.

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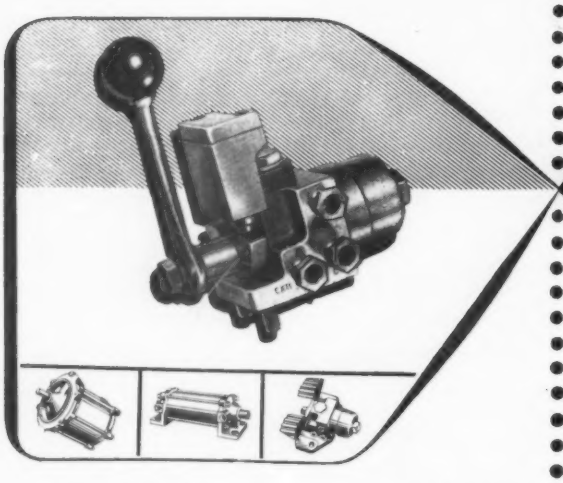

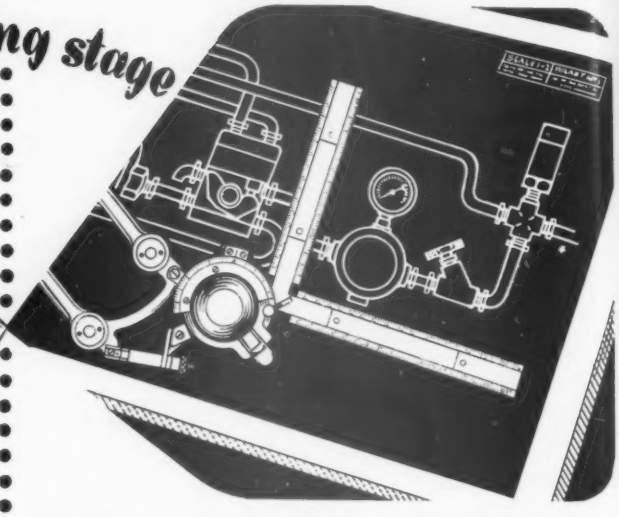

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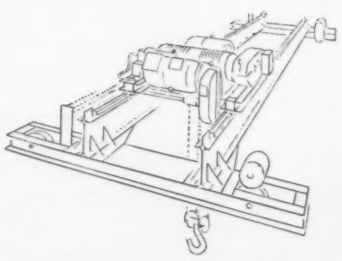

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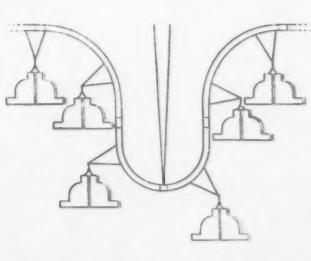

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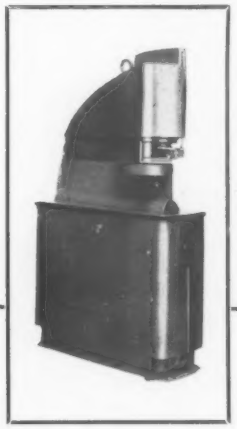

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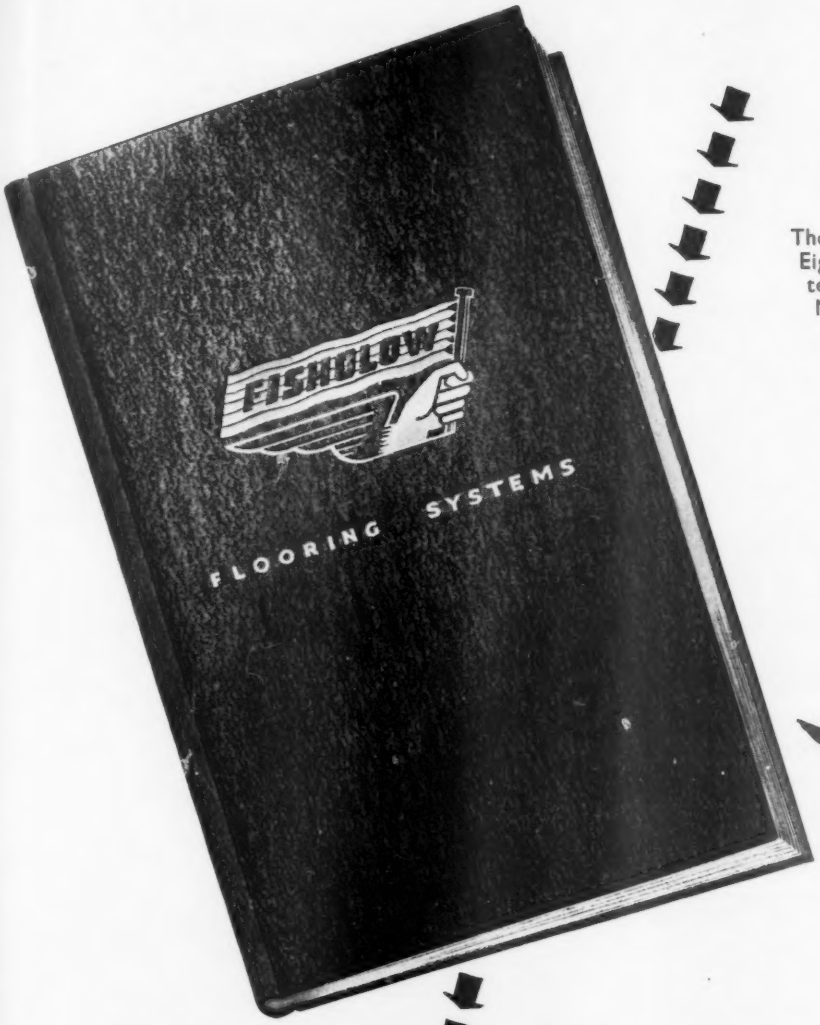

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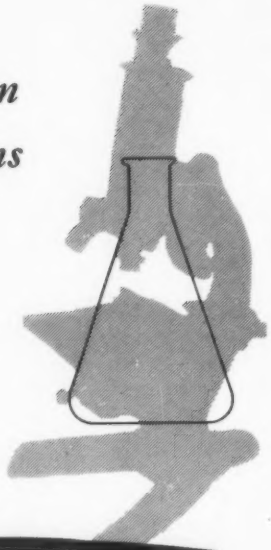

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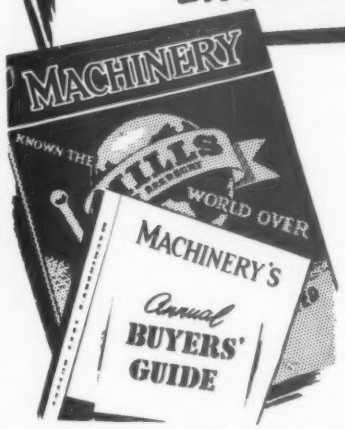

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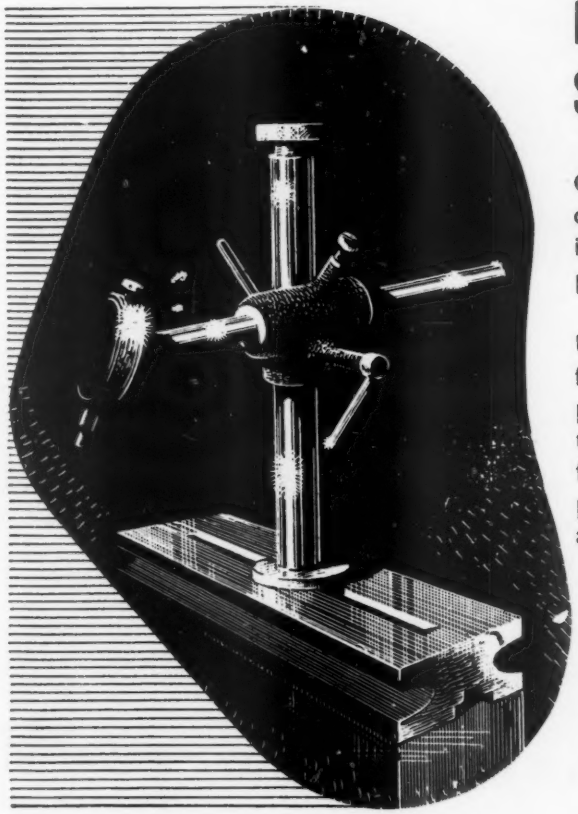

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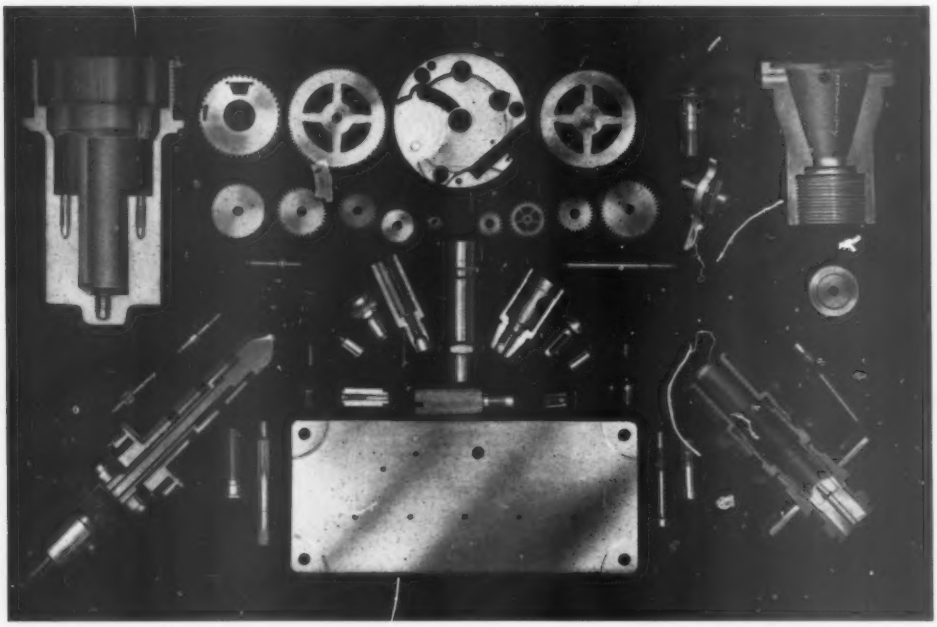

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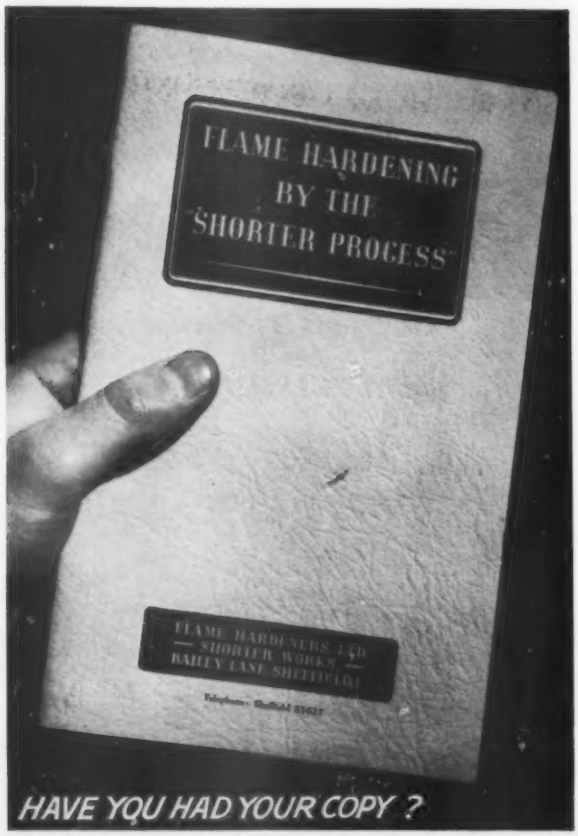

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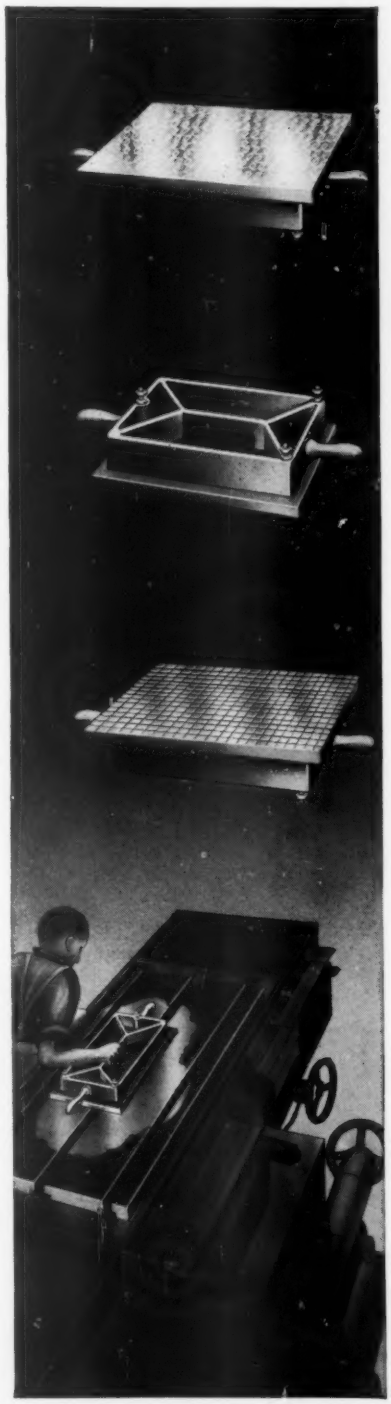

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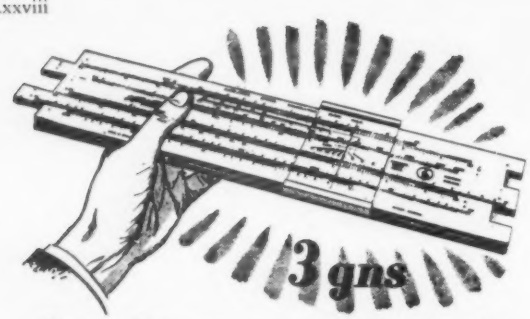

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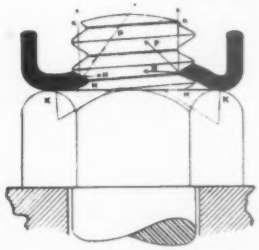

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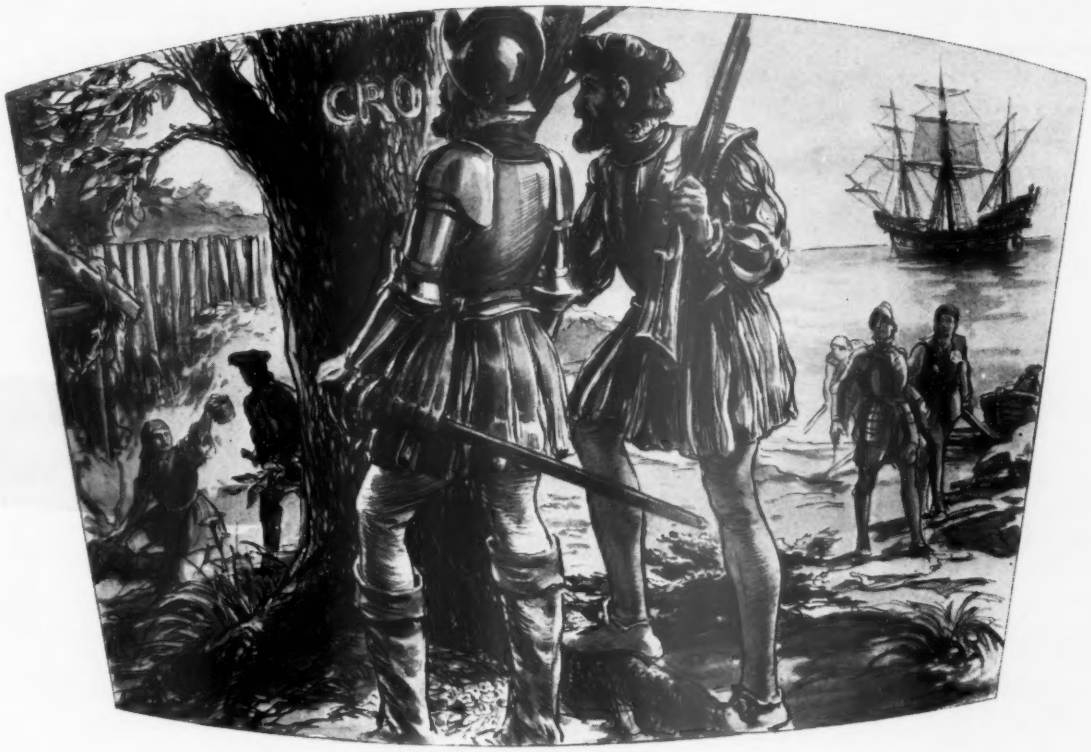

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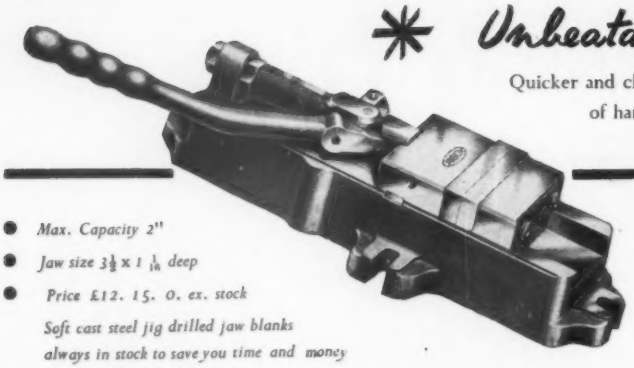

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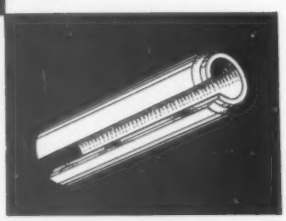

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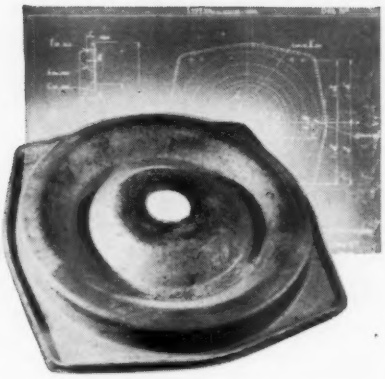

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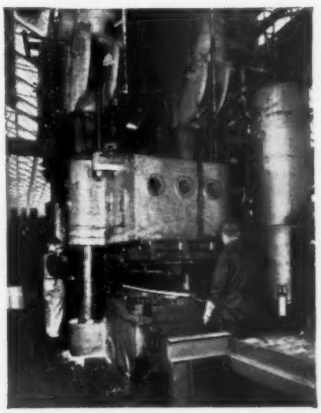

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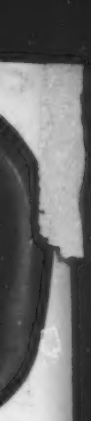

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JOURNAL SUPPLEMENT

Vol. 33, No. 12
DECEMBER, 1954

INSTITUTION OF PRODUCTION ENGINEERS, 10, CHESTERFIELD ST., LONDON, W.1

THIRD CONFERENCE ON

Problems of Aircraft Production

UNIVERSITY OF SOUTHAMPTON

14th and 15th January, 1955

The theme of this Third Conference is:

"Integral Construction contrasted with Traditional Methods"

and the programme has been so designed as to include Papers by leading authorities in addition to allowing ample time for questions and discussion.

The fee for the Conference (including the Conference Luncheon on Friday, 14th January, and refreshments) is 30s. for members and affiliate representatives, and 35s. for non-members.

Applications for tickets should be made on the form overleaf and sent to The Secretary, 10, Chesterfield Street, London, W.1. Tickets will be allotted in order of date of receipt of applications. **The closing date for applications is Wednesday, 5th January, 1955.**

CONFERENCE OF STANDARDS ENGINEERS

The Standards Committee is considering the possibility of holding, in conjunction with the British Standards Institution, a conference at which Standards Engineers can meet informally to discuss their joint problems. Before embarking on this venture, however, the Committee would like to have some indication of the possible extent to which members would support such a conference. Those members who approve the suggestion in principle and who would like further details when they are available are asked to complete and return the form below. The Committee will also be glad to know of any non-members who might be interested.

For the purpose of the Conference, the Committee has defined a Standards Engineer as "one who carries responsibility for the standardisation of a firm's tools, component parts, materials, etc., in the everyday practice and usage of the firm."

MEETINGS

Visitors tickets may be obtained from Section Honorary Secretaries

DECEMBER 1954

BIRMINGHAM 7.0 p.m. **DECEMBER 15th**
The James Watt Memorial Institute, Great Charles Street, Birmingham 3.
"Shell Moulding" by A. N. Wormleighton, and G. Hannaford.

BIRMINGHAM 7.30 p.m. **DECEMBER 18th**
The Botanical Gardens, Edgbaston, Birmingham.
Christmas Dance.

COVENTRY GRADUATE 7.15 p.m. **DECEMBER 7th**
The Hare & Squirrel Hotel, Cow Lane, Coventry.
"The Application of Scientific Administrative Methods to Engineering Production." by C. Cooper, A.M.I.Prod.E., A.M.I.I.A., M.I.Ec.E.

DERBY 7.0 p.m. **DECEMBER 13th**
The Midland Hotel, Midland Road, Derby.
"Any Questions." A Panel will answer questions submitted by members.

To: The Secretary,
Institution of Production Engineers,
10, Chesterfield Street,
London, W.1.

AIRCRAFT PRODUCTION CONFERENCE

1. *NAME* .....

2. *Grade of Membership* .....

2a. *Honours, degrees, other quals.* .....

3. *ADDRESS* .....

4. *NAME OF COMPANY* .....

5. *POSITION HELD* .....

N.B.—If more than **ONE** ticket is required, please supply information 1 to 5 above on a separate sheet of paper for each ticket applied for.

Please send me ..... members tickets at 30/-each for the Conference, } for which I enclose my remittance for £.....
Please send me ..... non-members tickets at 35/- each for the Conference } *Signature*.....

Date.....

Note.—Cheques, etc., should be made payable to: The Institution of Production Engineers.

To: The Secretary,
Institution of Production Engineers,
10, Chesterfield Street,
London, W.1.

CONFERENCE OF STANDARDS ENGINEERS

I am interested in the suggestion that an informal conference of Standards Engineers be held, and shall be glad to receive further details when they are available.

NAME.....
GRADE.....
ADDRESS.....
.....
.....

I suggest that details should also be sent to the following non-members who come within your definition of a Standards Engineer:

NAME..... *NAME*.....
ADDRESS..... *ADDRESS*.....
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....

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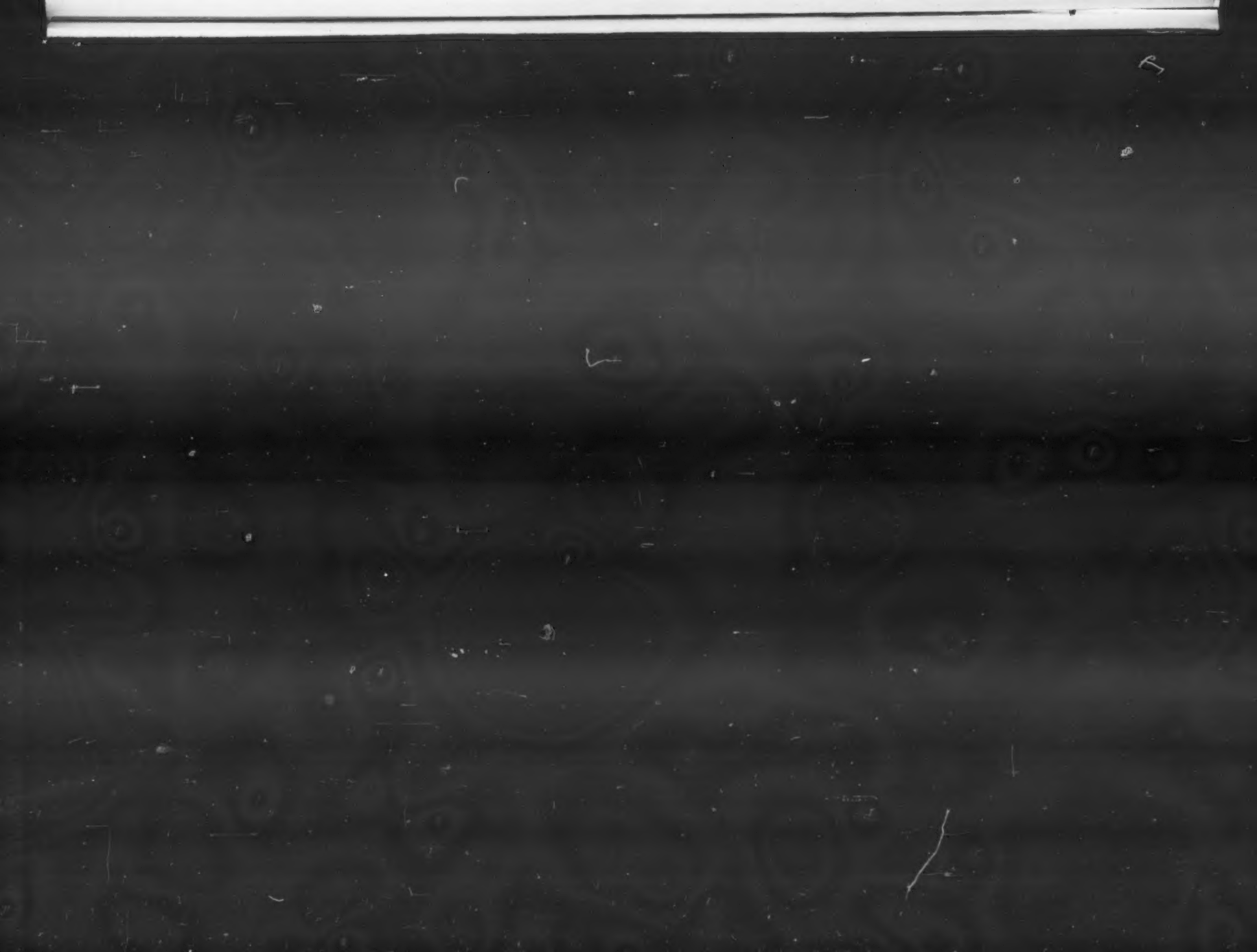

DONCASTER **7.0 p.m. DECEMBER 14th**
The Danum Hotel, Doncaster.
Informal Discussion. " What is Management ?"

DUNDEE **DECEMBER 8th**
A works visit to Messrs. Ferranti Ltd., Industrial Estate, Dundee.

EASTERN COUNTIES **7.30 p.m. DECEMBER 10th**
The Diocesan Hall, Tower Street, Ipswich.
" Plastics—Materials, processes and machines," by D. C. Nicholas.

GLASGOW **7.30 p.m. DECEMBER 16th**
The Institute of Engineers & Shipbuilders, 39, Elmbank Crescent, Glasgow, C.2.
" Work Measurement " by Prof. T. U. Matthew, Ph.D., M.Sc., M.I.Prod.E.

GLOUCESTER AND DISTRICT
7.15 p.m. DECEMBER 9th
The Cheltenham Motor Club, High Street, Cheltenham.
" Watch and Clock Production," by R. Lenoir, F.B.H.I. (Joint meeting with the Cheltenham Branch of the British Horological Institute.)

HALIFAX **7.15 p.m. DECEMBER 1st**
The George Hotel, Huddersfield.
" Production Panel "—composed of leading authorities from local industries.

HALIFAX GRADUATE **7.30 p.m. DECEMBER 9th**
Collinson's Cafe, Crown Street, Halifax.
" A Scientific Approach to Management "—Open Discussion.

LEICESTER **7.0 p.m. DECEMBER 9th**
The Balmoral Room, Bell Hotel, Leicester.
"Training as Related to Production Processes," by E. M. Price, M.I.Prod.E.

LINCOLN **7.30 p.m. DECEMBER 16th**
The Ruston Club, Unity Square, Lincoln.
" Material Utilisation," by F. Nixon, B.Sc.(Hons.), M.I.Mech.E., F.R.Ae.S.

LIVERPOOL **7.30 p.m. DECEMBER 8th**
The Picton Hall, Liverpool.
" British Standards in Production Engineering," by Dr. E. L. Diamond, M.Sc., M.I.Mech.E. (Meeting arranged in conjunction with City of Liverpool Public Libraries.)

LIVERPOOL **7.30 p.m. DECEMBER 15th**
The Adelphi Hotel, Liverpool.
" Cost Control," by H. H. Norcross.

LIVERPOOL GRADUATE
7.45 p.m. DECEMBER 20th
The Stork Hotel, Liverpool.
Film Evening.

LONDON **7.0 p.m. DECEMBER 16th**
The Royal Empire Society, Northumberland Avenue, W.C.2.
" Budgetary Control at Shop Floor Level," by F. T. Hunter, A.C.A., A.C.W.A.

LONDON GRADUATE **7.15 p.m. DECEMBER 14th**
The Institution of Production Engineers, 10, Chesterfield Street, London, W.1.
" The Production and Application of Engineering Parts prepared from Metal Powders " by L. Harrison, Ph.D., B.Met.

LUTON GRADUATE **8 p.m. DECEMBER 9th**
Works visit to Thermoplastics Ltd., Dunstable, Beds.

MANCHESTER GRADUATE
7.15 p.m. DECEMBER 2nd
Reynolds Hall, College of Technology, Sackville Street, Manchester.
" The Electronic Control of Machine Tools," by E. Hey A.M.I.E.E.

NORTH EASTERN **7.0 p.m. DECEMBER 20th**
The Neville Hall, Newcastle-on-Tyne.
Film Evening. Ladies are invited.

NORWICH **7.30 p.m. DECEMBER 3rd**
The Assembly House, Theatre Street, Norwich.
"Planned Maintenance " by O. F. Lewis, M.I.Prod.E.

NORTHERN IRELAND **DECEMBER 2nd**
The Lecture Hall, Ulster Farmers' Union, 18 Donegall Square, E. Belfast.
" They're Everywhere." A G.K.N. Film regarding nut and bolt production. Mr. Taylor, of Short Bros. & Harland Ltd., will give a short talk on the subject after the showing of the film.

NOTTINGHAM **7.0 p.m. DECEMBER 1st**
Victoria Station Hotel, Milton Street, Nottingham.
"Work Study Techniques " by L. G. Humble, A.M.I.Prod.E.

OXFORD **7.15 p.m. DECEMBER 14th**
Crawford & Co. (Tottenham) Ltd., Tower Hill Works, Witney, Oxon.
" Production Forum." Discussion Group.

PETERBOROUGH **7.30 p.m. DECEMBER 7th**
The Campbell Hotel, Bridge Street, Peterborough.
" Precision Casting " by J. S. Turnbull (Metropolitan Vickers Ltd.).

READING **7.30 p.m. DECEMBER 9th**
The Great Western Hotel, Reading.
" Copy Turning " by L. Lloyd.

ROCHESTER **7.30 p.m. DECEMBER 9th**
The Sun Hotel, Chatham.
" Shell Moulding " by M. C. Dixon, M.I.B.F., and R. S. Bushnell, A.M.I.B.F.

SHEFFIELD **6.30 p.m. DECEMBER 13th**
The Grand Hotel, Sheffield.
" Welding in the Atomic Energy Project " by I. H. Hogg, B.Sc., M.I.Mech.E. (Joint meeting with the Institute of Welding.)

SHREWSBURY **DECEMBER 10th**
Annual Dinner and Dance.

SOUTHERN **7.15 p.m. DECEMBER 16th**
The Polygon Hotel, Southampton.
" Impact of U.S.A. Financed Companies on Productivity in Great Britain " by J. H. Dunning, B.Sc.(Econ.). (Joint meeting with the Southampton Branch of the Institute of Cost and Works Accountants and the Southampton Local Productivity Committee.)

SOUTH ESSEX **7.30 p.m. DECEMBER 8th**
The Mid-Essex Technical College, Chelmsford.
" Shell Moulding " A Joint Paper and Demonstration, by M. C. Dixon, M.I.B.F., and R. S. Bushnell, A.M.I.B.F.

WESTERN GRADUATE **7.30 p.m. DECEMBER 6th**
The Grand Hotel, Broad Street, Bristol, 1.
" How Much Management Can We Afford?" by Mrs. Ruby A. Ord.

WEST WALES **7.30 p.m. DECEMBER 3rd**
The Central Library, Alexandra Road, Swansea:
" Planning for Production " by B. E. Stokes, A.M.I.Prod.E.

WOLVERHAMPTON **7.15 p.m. DECEMBER 1st**
Wolverhampton and Staffordshire Technical College, Wulfruna Street, Wolverhampton.
" Control of Production as Applied to the Manufacture of Small I.C. Engines " by D. Dudfield, B.A., A.M.I.Prod.E.

WOLVERHAMPTON GRADUATE
7.30 p.m. DECEMBER 15th
Wolverhampton and Staffordshire Technical College, Wulfruna Street, Wolverhampton.
" Some Aspects of Materials Handling in Industry " by D. J. H. Bridge, A.M.I.Prod.E.

WOLVERHAMPTON GRADUATE
7 p.m. DECEMBER 8th
Works visit to Ductile Sheets Ltd., Willenhall, Staffs.

YORKSHIRE **7.0 p.m. DECEMBER 6th**
The Hotel Metropole, Leeds.
" Electro Spark Machining " by A. D. P. Tallents, A.M.I.Prod.E.

YORKSHIRE GRADUATE **10 a.m. DECEMBER 11th**
Works visit to the Kirkstall Power Station, Kirkstall, Leeds.
Rendezvous: The Kirkstall Power Station, Leeds.

WESTERN **7.15 p.m. DECEMBER 14th**
Beaufort Room, Grand Hotel, Broad Street, Bristol 1.
" The Application of Work Study Techniques in the Furniture Industry " by R. H. Glossop.

JANUARY 3rd to 8th, 1955

COVENTRY GRADUATE **7.15 p.m. JANUARY 5th**
The Hare and Squirrel Hotel, Cow Lane, Coventry.
" Production Panel " Discussions on some Aspects of Production Engineering. Members of the panel: S. J. Harley, M.I.Mech.E., M.I.Prod.E. (Chairman), E. Beaumont, A.M.I.Prod.E., H. Peter Jost, A.M.I.Mech.E., A.M.I.Prod.E., E. M. Price, M.I.Prod.E., H. V. Field.

LIVERPOOL GRADUATE **9 a.m. JANUARY 8th**
Works visit to J. Bibby & Sons Ltd., Gt. Howard Street, Liverpool.

LONDON GRADUATE **JANUARY 6th**
Works Visit to Glacier Metal Co. Ltd., Ealing Road, Alperton.

NORWICH **7.30 p.m. JANUARY 5th**
The Assembly House, Theatre Street, Norwich.
" Fuel Efficiency in the Factory " by E. J. Tickner, B.Sc., A.M.I.Mech.E. (Joint Meeting with the Institute of Cost and Works Accountants.)

NOTTINGHAM **7 p.m. JANUARY 5th**
The Victoria Station Hotel, Nottingham.
" The Human Aspect in Production Planning and Control " by B. G. L. Jackman, M.I.Prod.E., A.R.Ae.S., M.I.I.A.

READING **7.30 p.m. JANUARY 6th**
The Great Western Hotel, Reading.
" Work Measurement " by Prof. T. U. Matthew, Ph.D., M.Sc., M.I.Prod.E.

SOUTH WALES AND MONMOUTHSHIRE
7 p.m. JANUARY 6th
The South Wales Institute of Engineers, Park Place, Cardiff.
" Standardisation in the Process Industries " by E. W. Greensmith, A.C.G.I., B.Sc., A.M.I.Mech.E. (Illustrated by lantern slides.)

WESTERN GRADUATE **7.30 p.m. JANUARY 3rd**
The Grand Hotel, Broad Street, Bristol 1.
" Rocket Propulsion " by Prof. A. D. Baxter, M.Eng., M.I.Mech.E., F.R.Ae.S., F.Inst.P.

WOLVERHAMPTON **7.15 p.m. JANUARY 5th**
The Anchor Hotel, Wednesbury.
" Lock Design and Manufacture " by C. G. Smith.

PRODUCTION APPOINTMENTS

BULLETIN No. 51

This bulletin is circulated to all members of the Institution monthly as near as possible to the first of the month. Firms or organisations wishing to insert notices in the bulletin should communicate with the Secretary at 10, Chesterfield Street, London, W.1.

The last date for receiving material for insertion in the following month's bulletin is the 20th of each month.
The fee for insertion of particulars regarding each appointment is £3 3s. (up to 100 words), and over 100 words £5 5s. No charge is made to firms affiliated to the Institution, Technical Colleges, Universities and similar organisations.
Advertisers are advised that better response is likely if, in addition to essential qualifications, the following information is given:-

(*a*) Location of appointment; (*b*) Status in the organisation and scope of promotion; (*c*) Salary range and age range.
Advertisers are asked to advise the Institution when appointments are filled. The Institution reserves the right to refuse or withdraw any announcement and also to make any alteration in the wording to ensure conformity with Institution standards.
Members interested in the following appointments should make application in accordance with the terms of notice. No correspondence can be undertaken by the Secretary other than the forwarding of replies to Box Nos.

All advertisements appearing in this Bulletin are subject to the Notification of Vacancies Order of 1952.

Chief of Progress with knowledge of machine loading and progressing jobs throughout required for large light engineering shop. 5-day week. Good salary to right man. Apply: Sterling Engineering Co. Ltd., Rainham Road South, Dagenham, Essex.

Time Study Engineers required for engineering company, covering the manufacture of electrical and mechanical components. Sound knowledge of machine shop practice and modern methods necessary. Good salary to right men. 5-day week. Staff canteen facilities. Apply: Sterling Engineering Co. Ltd., Rainham Road South, Dagenham Essex.

Production Engineer required by metal cap and box manufacturer in the Barking district. Applicants must have had extensive tool-making experience in this class of work, and be able to take charge of the Tool Room. Commencing salary £900 per annum. Apply in confidence, stating age and fullest details of experience to: The Managing Director, S. C. Lomax, Limited, Barking-By-Pass Road, Essex.

Process Planning Engineers. Applications are invited for Process Planning Engineers for a new project in one of the factories of a well-known Midlands Group. The persons concerned should preferably be of National Certificate standard and must have had considerable experience in deep drawing press work, and subsequent finish machining operations. The factory is a new one with all modern amenities, within easy reach of Birmingham, Wolverhampton and Walsall. Applications in the strictest confidence should be forwarded to: Box No. 935, I.Prod.E., 10 Chesterfield Street, London, W.1.

Work Study Engineers. The Bristol Aeroplane Company Limited requires two qualified and experienced Work Study Engineers to teach Work and Methods Study. These posts will be primarily instructional, but will provide opportunity for research and the practical application of work study in the Company's workshops. Good salary, Staff Pension Scheme and excellent working conditions. Applications should be addressed to the Chief Personnel Officer, Bristol Aeroplane Company Limited, Filton House, Filton, Bristol.

Industrial Consultants or engineers with considerable experience in production planning, work study and production control and who are University Graduates are invited to apply for a position on the Senior Production Staff of a well-known company with several factories in the Midlands and abroad. This is a high level appointment and will carry a salary from £1,500 to £2,500 depending upon experience. There will be opportunities for advancement to top level managerial positions within a few years. Age limits 25 to 40. There is a good pension scheme. All applications will be treated in strict confidence and should state age, qualifications and experience. Box No. 945, I.Prod.E., 10 Chesterfield Street, London W.1.

Technical Sales Representatives required—must have proven sales record; wide connections in Scotland, sound practical and technical engineering background; intimate knowledge of specialised precision machine tools. Reply setting out in chronological order details of education, training, experience and age to: Dowding & Doll Limited, 346 Kensington High Street, London, W.14.

Tool Engineer. Electro-Hydraulics Limited, Liverpool Road, Warrington, require Tool Engineer to take charge of departments covering Jig and Tool Drawing Office, Methods Planning, and Estimating, in engineering works designing aircraft and industrial hydraulics. First-class salary will be paid to suitable applicant who has the necessary experience, qualifications and initiative to control a staff of fifty. Age not to exceed 40 years. Applications to be addressed, in the first instance, to the Personnel Manager.

Stock Controller required by progressive manufacturing firm with 100 employees. Age limit 28/35 years. Applicant must be capable of working on own initiative and installing modern stock control system. Permanent position with pension scheme in operation. Box No. 946, I.Prod.E., 10 Chesterfield Street, London, W.1.

Senior Production Engineers. A number of qualified and experienced men are required by a large engineering organisation located near Wolverhampton to augment the staff of their

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central production engineering department. Preference will be given to men who have had wide production engineering responsibilities and possess specialised knowledge and experience in one or more of the following branches:—Methods, Time and Motion Study, Work Study, Jig and Tool Design, Production Control. The work will cover a wide range of products and include steel fabrications, press work, machine shops, precision engineering and assembly. There is plenty of opportunity for advancement within the group for candidates with suitable qualifications and the engineers appointed will be men of energy and ambition between 30 and 45 years of age. Full particulars with salary required should be addressed to Box No. 947, I.Prod.E., 10 Chesterfield Street, London, W.1.

Work Study Engineer, experienced in speed and effort rating and the application of incentive to direct and indirect labour on individual and grouped operations, is required by a light engineering company in the London area. An engineering apprenticeship is desirable. Considerable scope for a keen man in an expanding department. Superannuation with life assurance scheme. Apply in confidence giving age, salary required and full details of experience. Box. No 948, I.Prod.E., 10 Chesterfield Street, London, W.1.

Chief Planning Engineer aged 30 to 40 years, required to take charge of Planning Department in light engineering works in Slough area. Must be good organiser and fully experienced in all phases of engineering planning including press work, autos, capstans, finishing and assembly of small mechanisms and instruments in quantity. Previous experience in similar position essential. This is a senior staff appointment with excellent prospects and conditions and participation in pension scheme. Salary according to ability, but not less than £800 per annum. Details of positions held, training and qualifications to Box No. 949, I.Prod.E., 10 Chesterfield Street, London W.1.

Jig and Tool Draughtsmen with good experience on cam design, press work and jigs and fixtures, required for works in Slough area. Permanent progressive position with five day week, pension scheme, canteen, etc. Salary £650 per annum according to ability. Details of experience and training to Box No. 950, I.Prod.E., 10 Chesterfield Street, London, W.1.

Project Officer. Applications are invited for the post of Project Officer with the Gold Coast Industrial Development Corporation. Candidates should have served an indentured apprenticeship or have had at least 7 years practical experience in one or more of the manufacturing industries (preferably engineering) and subsequently held responsible technical or supervisory posts. Ability to assess the material, plant and labour requirements for new industries and to supervise the layout and installation of machinery, etc., is required. A knowledge of costing would be an advantage. Associate Membership of a recognised Engineering Institution or a H.N.C. is essential. Candidates should also be able to appreciate product design, make drawings and write clear concise reports. Initial salary will be fixed between £1,250-£1,500 per annum according to qualifications, experience, etc. Furnished accommodation at rates £60/£75 per annum. Contract period eighteen months with option for extension. Successful applicant will be required to join Corporation's Provident Fund, employee's contribution being calculated at 7½% and employer's at 17½% of salary. An officer recruited overseas would receive passages for himself, wife and three children below the age of 13, leave at the rate of seven days per month and outfit allowance of £30. A good knowledge of spoken and written English is essential. Applications stating age, qualifications, past and present employment and salary, and the names of three referees who have knowledge of the applicant's experience and who can vouch for his integrity may be sent in an envelope marked "Confidential" to the Adviser on Recruitment, Gold Coast Office, Melbourne House, Aldwych, London, W.C.2.

Service and Demonstration Engineer required for gear hobbing machines. Good workshop experience and technical training essential. Initial tuition given to suitable applicant. Write stating age, education, training, experience and technical qualifications to Box No. 951, I.Prod.E., 10 Chesterfield Street, London, W.1.

Assistant to Factory Manager. An opening occurs for a live and capable man with engineering background and preferably knowledge of modern production methods for cable facttory in the Manchester area. Good prospects for the right applicant. Apply giving details of past experience to Box No. 952, I. Prod.E., 10 Chesterfield Street, LondonW.1.

Production Methods Engineers required by light engineering Company in S.E. England. Wide range of process manufacture with limited machine shop operations. Experience, etc., should include, apprenticeship, design of tools and special purpose machinery, methods study, flow production, cost investigation. Pensionable posts within the salary range £700 to £1,000 according to qualifications and experience. Housing accommodation available. Write stating age, qualifications and experience to Box No. 953, I.Prod.E., 10 Chesterfield Street, London, W.1.

Workshops Superintendent. Applications are invited from men with considerable machine shop experience and of proved administrative ability for appointment as Superintendent of a number of machine shops engaged on varying batch production. The post will entail responsibility for meeting a machine shop production programme on day and night shift, the direction of the detail work of the departments, through the various machine shop foremen, the improvement of methods in conjunction with the Production Engineering Department, and the maintenance of good working relationships in the shops. The requirements of the post are a good shop floor experience over as wide a range of machine tools as possible and including expert capstan knowledge, with at least five years' supervisory experience in a large engineering works, together with an understanding of the practical application of machine utilisation and efficiency techniques. Applications giving full details of age, qualifications, experience and salary required to Box No. 954, I.Prod.E., 10 Chesterfield Street, London, W.1.

Works Production Manager required by old established engineering company in West Midlands to take sole charge of all production problems, mostly machine shop, including methods, rate-fixing and labour control. Must be really experienced Production Engineer. The post offers a generous salary and exceptional future prospects, including Directorship. Apply stating age and summary of experience to Box No. 955, I.Prod.E., 10 Chesterfield Street, London, W.1.

Senior Machine Tool Designers required by Snow & Co. Ltd., Sheffield, 3. To a top class designer of experience, ability and vision is offered an exceptionally good salary, opportunity to advance, and housing facilities. All applications will be treated in strict confidence—apply in the first instance in writing.

Chief Production Engineer. A prominent manufacturer desires to appoint a Chief Production Engineer with experience of electric lamp or valve manufacture. The position calls for a person having considerable experience in lamp making machinery and manufacturing methods. Prospects are excellent. A first-rate salary will be paid to the right man and the position is fully superannuated. Own staff are aware of the vacancy. Applications in full detail to Box No. 956, I.Prod.E., 10 Chesterfield Street, London, W.1.

Production Engineer required for factory (Wolverhampton Area), producing medium size welded fabrications on batch production basis. Applicants should be conversant with modern welding techniques and machine shop practice. Responsibility would include control of the following sections: tool drawing, planning and estimating, time and motion study, material and production control. This is a difficult job, but for the man possessing initiative and drive who is prepared to work hard in a rapidly expanding department the scope is wide and progressive. All applications will be treated in the strictest confidence and should contain fullest details to Personnel Manager, Box No. 957, I.Prod.E., 10 Chesterfield Street, London, W.1.

Graduate Engineers. A general engineering company in S.E. London requires a number of graduate engineers for training for future positions of responsibility within its organisation. Applicants should be within the age scale 28-35 and should have served an indentured apprenticeship in general engineering with subsequent works' training in a position requiring energy, drive and initiative. Apply giving full details of technical and practical training and experience to Box No. 958, I.Prod.E., 10 Chesterfield Street, London, W.1.

Production Planning Engineers. Standard Telephones & Cables Ltd., and Kolster-Brandes Ltd., Sidcup, Kent, require Production Planning Engineers, aged 22-35, for these progressive and pensionable posts:—

(1) **K.B. Radio T.V. Factory.** (*a*) B.Sc.(Mech.) or H.N.C.(Mech.) and trade apprenticeship with experience of light engineering assembly, jigs fixtures etc. Some experience

salary required to W. J. Yeomans, Personnel Manager.
of work study desirable. (*b*) H.N.C.(Mech.) and trade apprenticeship for trainee post. Production Planning experience not essential.
(2) **Brimar Valve & C.R.T. Factory.** 2 posts. H.N.C. and trade apprenticeship, preferably with experience of C.R.T. and Radio Valve manufacture. Write stating age, experience and

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Design Draughtsman capable of developing and designing special purpose machine tools with minimum supervision. East Coast of Scotland. Salary up to £1,000 per annum. Apply giving age and experience to Box No. 959, I.Prod.E., 10 Chesterfield Street, London, W.1.

Qualified Engineers. Aircraft Company in Greater London area invites applications from well qualified men with wide experience of aircraft manufacture or other light engineering, for appointment to senior positions in the pre-production and production departments. These executive positions, on the monthly staff, afford outstanding opportunity for advancement to Senior Management status. Applications, to include full details of present position, to Box No. 960, I.Prod.E., 10 Chesterfield Street, London, W.1.

Work Study Department Chief required to take control of department of 15 engineers at progressive works on the South Coast building high grade machine tools. Able man of good character with an advanced outlook regarding work study and payment by result technique, also with sound production engineering background, required. A good salary according to ability will be paid. Reply Work Study, C.V.A. Jigs, Moulds & Tools Ltd., Portland Road, Hove, 3.

Draughtsman required immediately, preferably experienced in sheet metal press tool design for components for the manufacture of heat exchange equipment for aircraft and automobile. Experience in production planning an advantage. Interesting work, good salary and prospects, contributory pension scheme, excellent working conditions, five day week. Apply: Marston Excelsior Limited, 49/67 Armley Road, Leeds 12.

Assistant Consultants. A. G. Hayek and Partners Ltd., Management Consultants and Industrial Engineers, invite applications for vacancies for Assistant Consultants. Applicants should be of H.N.C. standard and must have had practical experience of Motion and Time Study, and Methods Engineering; some knowledge of Production Control and Costing an advantage. Appointments are based on Stoke-on-Trent. Participation in profit sharing scheme after completion of probationary period. Apply in confidence with fullest details and salary requirements to above at Federation House, Stoke-on-Trent.

Jig and Tool Draughtsman required with at least 5 years' jig and tool experience. Write full particulars to Personnel Manager, Broom & Wade Limited, High Wycombe, Bucks.

Research and Development—man required to watch over new developments in engineering works. Compressed air experience essential. Full particulars to Personnel Manager, Broom & Wade Limited, High Wycombe, Bucks.

Production Engineer required by a prominent group with electrical and mechanical subsidiaries in the North West of England. This is a senior appointment and candidates must have had a wide experience in design considerations in relation to repetitive production, preferably in the electrical industry. The position is permanent and pensionable with a starting salary of not less than £2,000 p.a. with considerable opportunity for further advancement. Please apply giving full details of age, education, training and experience to Box No. 2J. L.5361 A.K. Advg., 212a Shaftesbury Avenue, London, W.C.2.

Chief Designer required by a group of electrical manufacturing companies in the North of England. This is a senior executive appointment and candidates must have originality, organising ability and drive. The successful applicant must be capable of building up a design staff *ab initio* and should preferably have experience in the design of contactors, overload protective devices, etc., and electrical equipment generally. The position is permanent and pensionable and carries a commencing salary of £2,000 per annum with considerable opportunities for the future. Please apply giving details of age, education, training and experience to Box No. 2 J.L. 5369, A.K. Advg., 212a Shaftesbury Avenue, London, W.C.2.

Materials Handling Engineer. H.N.C. Final City and Guilds or equivalent. Must have had some experience in materials handling in connection with line or semi-line production. The successful applicant will be required to study and introduce materials handling methods at a sub/factory in North Wales for approximately 12/18 months, with a view to installing an efficient materials handling scheme into a new factory which is shortly to be constructed on Merseyside. Applications are invited from young engineers of approximately 30 years of age, who are willing to commence at a salary of £700/750 per annum, with a view to further advancement as position develops. Box No. 961, I.Prod.E., 10 Chesterfield Street, London, W.1.

Chief Ratefixer. Applications are invited for the position of Chief Ratefixer to the National Gas & Oil Engine Co. Ltd. The Company produces a wide range of oil, gas and dual fuel engines, and experience in line, batch and job rate-fixing is required, together with individual and group incentive schemes. The post is a permanent senior staff appointment, and the Company operates a contributory pension scheme. Applications should be addressed to the Personnel Manager, National Gas & Oil Engine Co. Ltd., Ashton-under-Lyne.

Production Manager. A company which has been established for nearly fifty years in a British Colony and is entirely British owned and financed requires a senior executive as Production Manager in its Head Office organisation, which controls six manufacturing units. The successful applicant must have proved organising and management ability and have held a post of equal responsibility to that now offered. Specialised knowledge of the industry concerned not essential. Age limit 45 years. Married man preferred. Excellent remuneration. Amenitirs offered include: accommodation, medical insurance scheme, home leave and free passages for wife and family. Replies will be treated in the strictest confidence and should give full details of education, training and positions held, in chronological order. Box No. 962, I.Prod.E., 10 Chesterfield Street, London, W.1.

Work Study Engineers are required for the electrical engineering subsidiary companies at Chester and Bedford and for the mechanical engineering subsidiary companies at Bromborough (Wirral) and Shrewsbury of Metal Industries Limited. Applicants should have a wide knowledge of method study and work measurement. The posts call for initiative, tact and constant application of effort; they are permanent and pensionable and carry a salary commensurate with ability and experience. Please apply giving full particulars of education and training, experience, etc., to the Group Training and Personnel Officer, Metal Industries Limited, 60 Buckingham Palace Road, London, S.W.1.

Methods Engineer—Crompton Parkinson Ltd., invite applications for a post in the Methods Department of their Doncaster factory. The duties include the technical direction of methods in connection with pressure diecasting in all its aspects, as applied to the manufacture of F.H.P. motors and units. A knowledge of subsequent machining operations would be an advantage. This post is particularly suitable for a Graduate possessing the required experience. The Company operates a Superannuation Fund to which employees contribute when eligible. Apply to Personnel Officer, giving details of qualifications, experience age and salary required.

Production Engineer required to control a newly established precision, light and general engineering factory. Applicants must be able to estimate, quote firm prices, maintain tight delivery schedules, and be responsible for process planning, design and manufacture of fixtures, jigs and tools, shop loading, production control, and the complete routing of all work through the factory which consists of some 40 latest type machine tools with a labour force of 50, which will eventually be built up to 200. Applicants will be expected to advise on the purchase of bought-out materials, correct utilisation of labour, stores, inspection and quality control. It is essential that applicants have technical qualifications to H.N.C. in Production Engineering, practical training in drawing office, toolroom and production departments, with up to date knowledge of machine tools, methods, planning and design. This is a permanent position with exceptional prospects and there is a modern house which goes with the job. Full details of experience and salary required to the Personnel Manager, Enham Industries, Andover, Hants.

Production Engineer conversant with modern methods capable of controlling planning and ratefixing of a medium/heavy firm of engineers. Good salary and working conditions. West Midlands area. Applications should give full details of experience and qualifications in confidence to: Group Personnel Director, Box No. 963, I.Prod.E., 10 Chesterfield Street, London, W.1.

Chief Ratefixer required by well-known West Midlands engineering Company. Must have experience in modern production planning methods and full knowledge of rate fixing. Write stating full particulars of experience, qualifications and salary required to: Group Personnel Director, Box No. 964, I.Prod.E., 10 Chesterfield Street, London, W.1.

Production-Works Manager required for section of a Group, to take charge of large automatic production of a specialised article, together with a smaller general engineering shop. Position calls for an engineer with sound knowledge of the latest automatic production methods, estimating, cost control, and organising output to delivery schedules. He must be capable of co-ordinating through the shop foreman, the details, management, and output of the departments, also the control of labour. He must be able to maintain customer contact on technical information, prices and deliveries. Applicants should preferably have had similar previous experience, but the position offers unlimited scope to a person with initiative, ideas and drive. Location Midlands country town. State age, education, qualifications, previous positions held and salary required. Permanent position with pension scheme to suitable applicant. Box M.2305, John Haddon & Co. Ltd., Salisbury Square, London, E.C.4.

General Manager. Large aircraft manufacturers require a General Manager for one of their subsidiary factories in the North which has a total labour force exceeding 2,000. The appointment, which will carry a salary of not less than £2,500 p.a., offers an excellent opportunity to a man of outstanding ability, preferably with good knowledge and experience of aircraft production. Applicants should write, giving full details of their career and date of availability, to Box I.E.559, c/o 191 Gresham House, E.C.2. All replies will be treated as strictly confidential.

Chief Production Engineer required by medium size light engineering Company in North London. Duties will include supervision of work study, incentives, production control, process planning, methods, factory layout, etc. Salary according to qualifications. Pension scheme. Assistance with housing and removal expenses if necessary. Write giving full details of training and experience with indication of present salary level, in confidence, to General Manager, Box No. 965, I.Prod.E., 10 Chesterfield Street, London, W.1.

Senior Work Study Engineer required by light electrical engineering firm in the London area. Applicants must be fully experienced in speed and effort rating, capable of controlling and directing other work study engineers, have had experience of batch production and the building and application of synthetics. A commencing salary between £850 and £1,000 per annum will be offered according to qualifications. Please reply, giving full particulars of experience and qualifications to Box No. 966, I.Prod.E., 10 Chesterfield Street, London, W.1.

Consulting Management Engineers require Production Engineers with sound experience in works layout, design, methods of manufacture, and work study. Engineering qualification (University degree or equivalent) essential. Age 33-45. Preference to those having successful managerial experience. Substantial salary and attractive prospects for successful men; contributory pension scheme. Write stating qualifications, experience and salaries received to Box No. 967, I.Prod.E., 10 Chesterfield Street, London, W.1.

Chief Work Study Engineer is required by a large engineering firm in the Midlands. This is a new appointment and only men with considerable executive experience, combined with knowledge and practice of modern methods, should apply. The successful applicant will be required to build up and control a large Work Study department and education of supervision and labour will be of prime importance. The salary will be in excess of £1,500 p.a. Apply in writing with full particulars of experience to date. Box No. 968, I.Prod.E., 10 Chesterfield Street, London, W.1.

Method Study and Production Control. A position has arisen in our organisation for a man who could initiate and organise a department devoted to method study and production control. Experience of mass production woodworking, although not essential, would be an advantage. Applicants should state age, full details of experience and an indication of salary required. In confidence to: Managing Director, H. Massil & Sons (Woodturners) Ltd., Welham Green, Hatfield, Herts.

Time and Motion Study Engineer. Glassworks require Time and Motion Study Engineer with general experience. Good scope for right man. Successful applicant eventually to take charge of small works. Write details, references, salary required English Glass Co. Ltd., Empire Road, Leicester.

Young Engineer. W. & A. Gilbey, Ltd., London, N.W.1., distillers and bottlers of wines and spirits, wish to engage a young engineer (graduate) with a view to his ultimately assuming executive management of their plant in London with general supervision of their plants elsewhere in Britain and in the Dominions. Apply to Secretary, Gilbey House, Oval Road, London, N.W.1.

Personal Assistant—age 25/35 years—required by Managing Director of firm manufacturing small to medium sized automatic boilers in Surrey. Loyalty and initiative, coupled with good technical training and Works experience essential. Excellent prospects for the right man. Send full particulars to Box No. 969, I.Prod.E., 10 Chesterfield Street, London, W.1.

Production Planning and Control. Assistant Production Controller required by large international manufacturers of domestic appliances, employing over 2,000 in the Home Counties. Applicants, age 28-38, must have previous experience in factories of a similar nature engaged on series production. Essential to be fully conversant with modern production planning and control techniques, with especial reference to time and quantity scheduling, shop loading and order control, etc. First class opportunity for the right man. Write stating age, training, qualifications and full details of experience in chronological order to Box No. 970, I.Prod.E., 10 Chesterfield Street, London, W.1.

Good Lecturer on Work Study in its broadest sense required to take charge of touring demonstration unit. Must be an enthusiast with practical experience of application and ability to talk to all levels of industry on this subject. Salary according to experience and professional qualifications. Apply, giving full particulars of education, training and experience, to British Productivity Council, 21 Tothill Street, London, S.W.1.

Work Study Engineer required for medium sized engineering Company in the centre of Huddersfield. A fully trained man is preferred, but consideration will be given to young engineers who would like to be taught the technique. Salary according to age and qualifications. Excellent working conditions, canteen and pension scheme. This is an opportunity for a keen man to participate in an interesting and worthwhile development. Apply to Box No. 971, I.Prod.E., 10 Chesterfield Street, London, W.1.

Qualified British Engineer. A British engineering concern requires an experienced and fully qualified British engineer, age 35 to 45 and medically fit, as General Works Manager in the Company's large Calcutta Works, comprising rolling mills, forging presses, automatics, etc., etc. Contributory provident scheme optional and there is a non-contributory pension scheme. The appointment carries free medical benefits, free accommodation or allowance in lieu, and passages self and family. Four months paid leave after three years. Apply Box No. 972, I.Prod.E., 10 Chesterfield Street, London, W.1.

Chief Inspector. The Mettoy Company Limited invite applications for the post of Chief Inspector at their Swansea Works. The Company is engaged in the manufacture of mechanical toys and engineering products in tinplate, plastics and die-casting, and the successful candidate will answer to the Managing Director for the effective administration and development of all inspection and quality control procedures. This is a senior appointment calling for first class qualifications and experience, and the following minimum requirements:—

1. An unchallengeable familiarity with light engineering inspection and quality-control techniques for mass and batch production.
2. Employment (with reputable organisations) in Management or senior Supervisory capacities.
3. Technical qualifications of Higher National Certificate standard.

The post is permanent and carries entitlement to membership of the Company's Contributory Pension Scheme. Intending candidates are asked to write fully, and at once, giving a detailed history of their qualifications, experience, and progress to date, and marking the envelope "Confidential: for the attention of the Managing Director."

Chief Methods and Work Study Engineer. The Mettoy Company Limited, Swansea, seek the services of a Chief Methods and Work Study Engineer, who shall be competent by training and experience to head-up a Department concerned with Methods and Work Measurement in the mass production of mechanical toys and light engineering products. Candidates must be familiar with power presses, injection moulding and conveyor assembly. The post is answerable to the General Works Manager. Essential qualifications are a progressive career in methods and time-study in light industry (perhaps electrical, radio or small mechanisms) and evidence of training for this work at the appropriate level. This is an important pensionable appointment and applications will be acknowledged and treated in strict confidence. Candidates are invited to address themselves to the Managing Director, marking the envelope "Confidential."

Production Engineer. A rapidly expanding engineering concern in the West Riding, specialising in production of domestic electrical equipment requires a Production Engineer to take charge of process planning, jig and tool design, layout, works study, etc. Only qualified engineers with proven experience in a similar executive capacity who can justify a four figure salary should apply. Applications, which should detail age, education, qualifications, experience, will be treated in strict confidence. Apply Box No. 973, I.Prod.E., 10 Chesterfield Street, London, W.1.

Work Study Engineer. Work Study Engineer, aged 35/45, required by North West Engineering Firm, employing over 2,000 to develop and control this department and work in liaison with the Works Cost Department. Applicants must have had first class experience in modern engineering works, or with first class firm of consultants. The firm's own specialised products cover a very wide range; the plant is extremely varied, and entirely modern. The post is responsible and progressive, with commensurate salary and excellent pension scheme. Box No. 974, I.Prod.E., 10 Chesterfield Street, London, W.1.

Senior Designer, aged 40/45, required to take charge, under older Chief Designer, of administration of Drawing Office in North West Engineering Firm, employing over 2,000 on own varied and specialised products. The post is essentially administrative and will require the fullest management experience and drive so as to develop modern drawing office organisation and training. He will be required to guide and co-relate activities of designers rather than to design in what will probably be a new type of product, and prior experience and achievement in machine design is essential; only men of sufficient standing to gain respect will be considered. First class salary and excellent pension scheme. Apply to Box No. 975, I.Prod.E., 10 Chesterfield Street, London, W.1.

Methods Engineers required by Black & Decker Limited, Harmondsworth, Middlesex (near London Airport). Experience of work measurement, methods study, tool design and plant layout for machining, winding and assembly processes as applicable to the large batch production of F.H.P. motors or similar products, essential. Generous salary offered to experienced men; 5-day week (37½ hours). Write full details age, practical and technical experience and present salary to Personnel Manager.

Senior Electrical and Production Engineers. Aircraft Company in Greater London area has vacancies for Senior Electrical and Production Engineers for work on all aspects of aircraft manufacture. Applicants for these executive positions should possess qualfications, experience and ability to enable them to earn four figure salary within short time of appointment. Applications to include full details of experience and present position to General Manager, Box No. 976, I.Prod.E., 10 Chesterfield Street, London, W.1.

Technical Officer. Applications are invited for appointment as the Council's Technical Officer in the West of England, with headquarters in Bristol or London. The duties will include co-ordinating and assisting the activities of the local Productivity Committees in that area. Applicants must have a sound industrial background, preferably in the field of industrial engineering and must be prepared to accept responsibility. Salary will be commensurate with qualifications and experience. Applications should be made in writing as early as possible to the Secretary, British Productivity Council, 21 Tothill Street, London, S.W.1., giving age, and full details in chronological order of education, professional qualifications and positions held.

EDUCATIONAL APPOINTMENTS

The New South Wales University of Technology, Sydney, Australia.

Vacancy for Associate Professor in Production Engineering. The University invites applications for the position of Associate Professor in Production Engineering, in the School of Mechanical Engineering. Salary £A1,950 per annum. Applicants should possess a high academic qualification and have extensive production experience. The appointee will be required to take charge of the Diploma and Certificate courses in Production Engineering under the general direction of the Head of the School of Mechanical Engineering; to direct a programme of expansion to meet industry's needs for trained production engineers, and to initiate and direct research into production engineering problems. The appointee will be eligible, subject to medical examination, to contribute to the New South Wales Superannuation Fund, which will provide a pension of £A1,014 per annum. First class shipping fares to Sydney of appointee and family will be paid. The University reserves the right to fill the position by invitation. Further particulars may be obtained from Professor A. H. Willis, Head of the School of Mechanical Engineering, Sydney. Five copies of applications, with testimonials and other supporting documents, should be lodged with the Agent General for New South Wales, 56/57 Strand, London, W.C.2., before 21st December, 1954, also one copy of application should be forwarded by air mail to the Bursar, N.S.W. University of Technology, Broadway, New South Wales, Australia, by the same date.

Coventry Technical College, Coventry.

Assistant Grade B (1 vacancy), Assistant Grade A (3 vacancies).

Applications invited for the following full-time teaching posts as from 1st January, 1955, or later by arrangement. Candidates should be graduates, or hold good technical qualifications. Previous teaching experience advantageous. Mechanical Engineering Department: Assistant Grade B (1 vacancy); Assistants Grade A (3 vacancies). Applications considered from those experienced in some branch of Mechanical, Automobile or Production Engineering. Salary 1954 Burnham Technical Scales:—Assistants Grade B—£525 x £25—£820. Assistants Grade A—£450 x £18—£725. Application forms from Director of Education, Council House, Coventry, returnable without delay.

Loughborough College of Technology, Loughborough.

Shop Superintendent, Tool Room and Grinding Departments. Applications are invited for the position of Superintendent of the Tool Room and Grinding Departments. The person appointed will be responsible for the practical instruction of full-time engineering students in Engineering Workshops Production Processes, and for production. Applicants should hold the Final Certificate in Machine Shop Engineering of the City and Guilds of London Institute, or a Higher National Certificate in Production Engineering, or an equivalent qualification. Good industrial experience is essential, including experience in Tool Room and Gauge Work, Precision Grinding and Tool Grinding and Precision Measurement. Salary will be paid according to the scale for Assistant Lecturers, Grade B, of the Burnham Committee Report, 1954, namely:—£525 x £25—£820. Application forms and further particulars may be obtained from the Registrar, to whom completed applications should be returned as soon as possible.